TRAFFIC SAFETY

IMPROVEMENT STUDY

WO No. 91-06

CITY OF BILLINGS

Yes-
MT
DOT
funding

PREPARED BY

MARVIN & ASSOCIATES
Traffic, Transportation & Civil Engineers

TRAFFIC SAFETY

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PREPARED FOR

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1127 ALDERSON AVE. 3204

BILLINGS, MT 59102

AND

ENGINEERING INC.

CITY OF BILLINGS

STUDY REFERENCE SHEET

Study Purpose & Objective:

To identify the twenty five most hazardous traffic locations not on the Federal Aid Street System within the City of Billings; perform data collection and analysis according to FHWA-RD-77-83 Methods; evaluate and recommend improvements; prioritize the sites; and prepare a report to be submitted to MDoT for funding through Off-System Safety funds.

Study Cost: $25,000.00

Study Funding: Montana Department of Justice - 100%

Contract Time: 120 Days

Notice to Proceed Date: October 1, 1991

Date Completed: March 3, 1991

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INTRODUCTION

STUDY PURPOSE

The City of Billings, in an effort to reduce or otherwise alleviate problems at accident cluster sites on the City street system, retained the Consulting Engineering Firm of Marvin & Associates to perform a traffic engineering study. The purpose of this study was to identify accident cluster locations, collect and analyze pertinent data, make short and long term safety improvement recommendations and establish a priority list of improvement projects.

Other studies using similar methods have been completed for Montana counties with the technical and fiscal assistance of the Montana Department of Justice, Highway Traffic Safety Division. The intent of the Highway Traffic Safety Division in sponsoring studies on county roads was to reduce accidents on county road systems and to establish an awareness of accident reduction measures so that a continuation of the program could be established within each county. After a decade of such work, Highway Traffic Safety has shifted its emphasis to city street systems. This is one of the first such studies to be completed within Montana's Cities.

Since most major cities in Montana have traffic engineers or technicians on staff and are benefited by other safety programs, the intent of the safety improvement study is somewhat different. Much of major urban area street systems are designated as Federal Aid Routes. The classifications range from Primary Highways to Federal Aid Urban streets. These streets are usually urban arterials and collectors which have high traffic volumes. Monitoring accident data and traffic volumes; developing improvement projects; planning new facilities; and maintaining the system, is usually handled by the City and State. Programs such as the TSM Element of the Transportation Planning Process and the Montana Department of Transportation's Safety Program adequately cover most of the safety problems within Montana's major cities. Day-to-day operations on the street system cover accident problem areas as they are brought to the attention of the city staff through citizen complaints or police requested investigations. The intent of this study is focused on

those locations which may not be included in any of the formal State or City programs. All of the accidents site are on streets which do not fall under Federal Aid classifications and are commonly known as "Off-system" streets. Some of the study sites may be at locations that the City has implemented controls in the past, but have defied efforts at improving safety. The majority of sites are usually low volume streets which have had minor, but consistent accident problems. Because of a low number of accidents per year, these locations are not readily recognized as accident cluster sites. When subjected to intense analysis as contained in this study's methods, large benefits from simple inexpensive improvements at these locations can be recognized. Thus, the purpose of this study is to identify accident cluster sites on Off-system city streets; recommend improvements; prioritize site improvements; and introduce cities to the methods used in this type of analysis.

The methodology used in this study, which primarily serves as the basis for the analysis within this report, can be found in the report *No. FHWA-RD-77-83 "Identification of Hazardous Locations"*. Refinements to the FHWA report made by *DCA Project No. 79-04-01-01* and subsequent county studies throughout the state, are also incorporated within this report. The methodology used to establish priority rankings is explained in the Benefit/Cost Ratio section of this report and is tailored specifically to the City of Billings' unique requirements.

Traffic safety improvements contained within this report will qualify for the Montana Department of Transportation, Off-system Safety Funds. Because of this, priorities and funding obligations are specifically tailored to MDoT requirements. Upon approval by the City of Billings, this report should be submitted to MDoT as justification for Off-system Safety fund allotments.

REPORT ORGANIZATION

The initial section of this report contains narratives describing the accident cluster site locations, characteristics of the city street system, study methodology, results of the hazard index analysis for all of the sites, explanation of the improvements recommended, priority index calculations, an implementation schedule and recommendations for continuation of the program in future years. Special attention should be

given to the Site Characteristics and Explanation of Improvements sections, since specific traffic safety information for the Billings street system is presented in these sections.

Site specific data can be found within the individual site sections following the main body of this report. Site specific sections contain brief narratives regarding site conditions, observed problems, and recommendations. Also included is an accident summary page, 35mm pictures of the site, and supporting information as required.

A great deal of computer generated data was printed and reduced for inclusion on the existing condition and short term improvement sketches. The availability of pertinent data on the same page as the sketches hopefully aids in comprehension of the problem identification and improvement benefits. The short term plan sketches can also be used by the MDoT to verify the traffic control device items eligible for funding through their program. These sketches, being too voluminous for inclusion within this report, are bound separately as a plan package. Any references to existing conditions or short term improvements within this report can be found in the that document. The 11"x17" plan sketch book can also be used by the City Street Department in the future, as a set of plans for actual implementation of most improvements.

The site specific sections of this report are numbered according to their priority ranking as indicated in the site location section of this report. Twenty five (25) sites are included in this project, as per the contract budget. Some of the sites were located in close proximity along single streets. In addition, other sites identified during the screening process indicated that some streets have accident problems at almost every intersection and significant numbers between intersections. At these locations a general evaluation of the corridor was completed. In this case, the Lewis Avenue and North 30th Street corridors are discussed within the main body of the report.

SITE CHARACTERISTICS

SITE LOCATIONS

The map on the following page (Figure 1.) shows the twenty five accident sites numbered according to their respective priority numbers. Table 1., below, is a listing of site numbers corresponding to the site locations:

TABLE 1. LIST OF STUDY SITES

PRIORITY NUMBER	AVENUE	STREET
1	AVENUE B	19TH STREET W
2	FOURTH AVENUE S	S 39TH STREET
3	ALDERSON AVENUE	3RD STREET W
4	HOWARD AVENUE	11TH STREET W
5	HOWARD AVENUE	10TH STREET W
6	YELLOWSTONE AVENUE	1ST STREET W
7	LEWIS AVENUE	1ST STREET W
8	ELEVENTH AVENUE N	N 30TH STREET
9	LEWIS AVENUE	6TH STREET W
10	SECOND AVE S	S 39TH STREET
11	THIRD AVENUE N	N 31ST STREET
12	TENTH AVENUE N	N 31ST STREET
13	SECOND AVENUE N	N 31ST STREET
14	SECOND AVENUE N	N 24TH STREET
15	THIRD AVENUE N	N 23RD STREET
16	POLY DRIVE	VIRGINIA LANE
17	SECOND AVENUE N	N 28TH STREET
18	TWELFTH AVENUE N	N 30TH STREET
19	PARKHILL DRIVE	13TH STREET W
20	WYOMING AVENUE	1ST STREET W
21	LEWIS AVENUE	10TH STREET W
22	THIRD AVENUE N	N 25TH STREET
23	LEWIS AVENUE	8TH STREET W
24	LEWIS AVENUE	19TH STREET W
25	POLY DRIVE	13TH STREET W

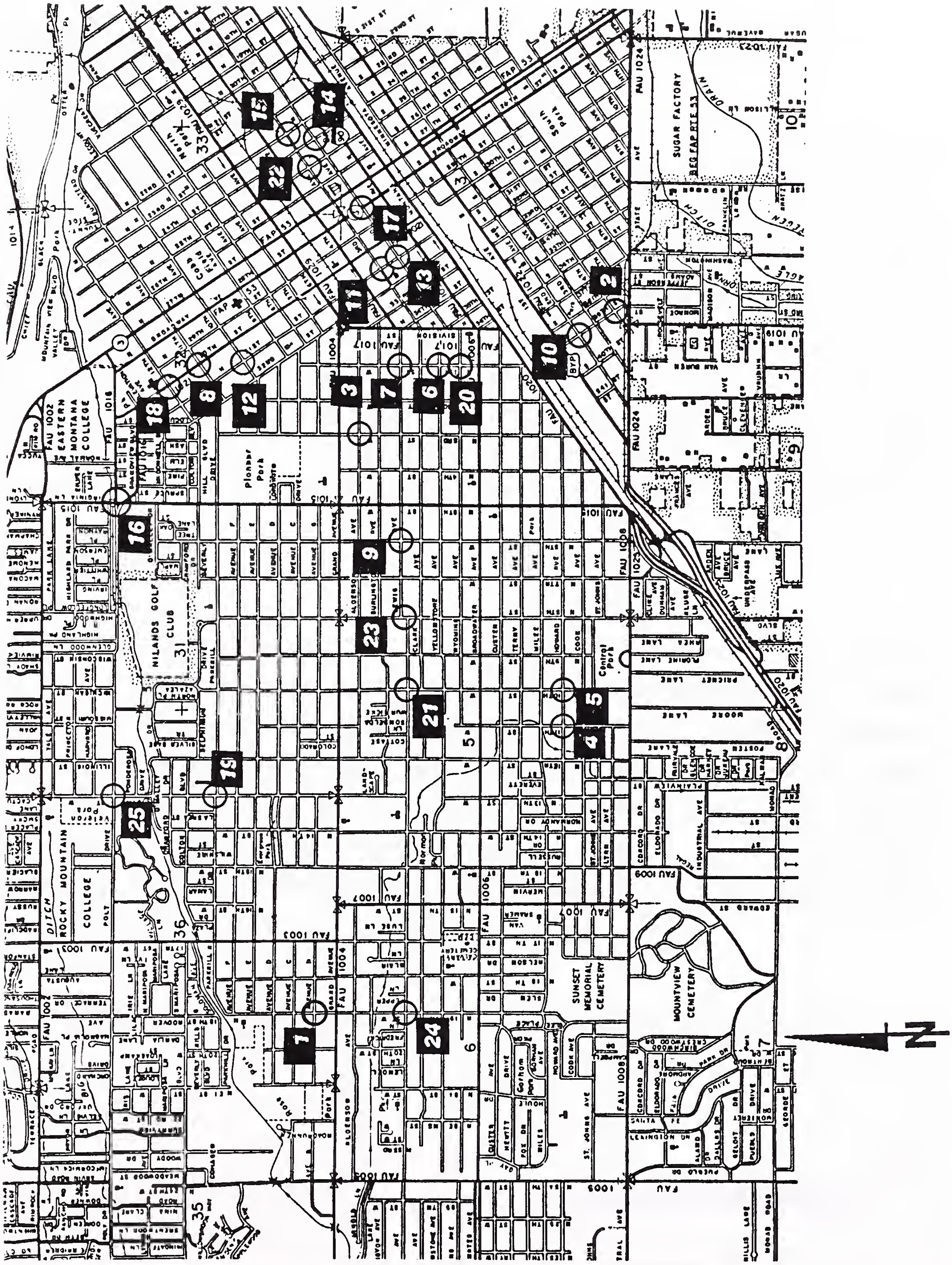


FIGURE 1. SITE LOCATION MAP

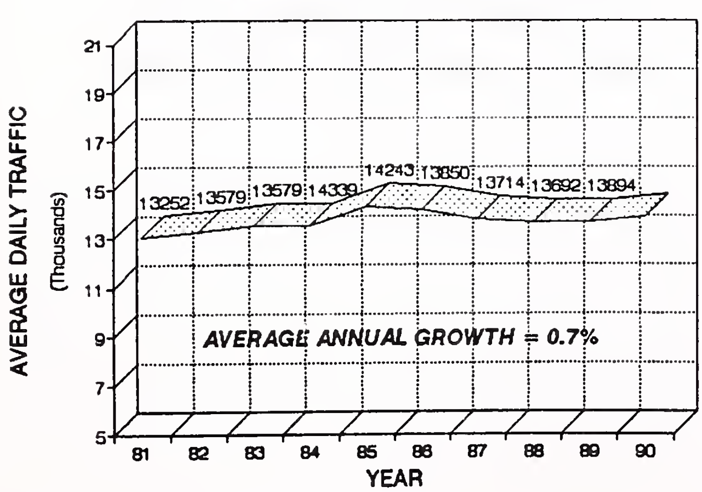
SYSTEM CHARACTERISTICS

Traffic Volumes - All of the accident sites are located in a completely urban environment on relatively low volume streets. The highest traffic volume at any site is approximately 20,700 vehicles per day entering an intersection, while the lowest volume is approximately 1300 vehicles per day entering. The average of all sites is approximately 7,700 vehicles per day entering. Average Daily Traffic (ADT) on all of the streets involved is approximately 3,800 and ranges between 14,500 and 300. The City of Billings provided numerous past traffic counts at or near the study sites. The Montana Department of Transportation monitors traffic at several permanent count stations in the Billings area. The information taken from these count stations was used to develop factors in estimating ADT's at the study sites.

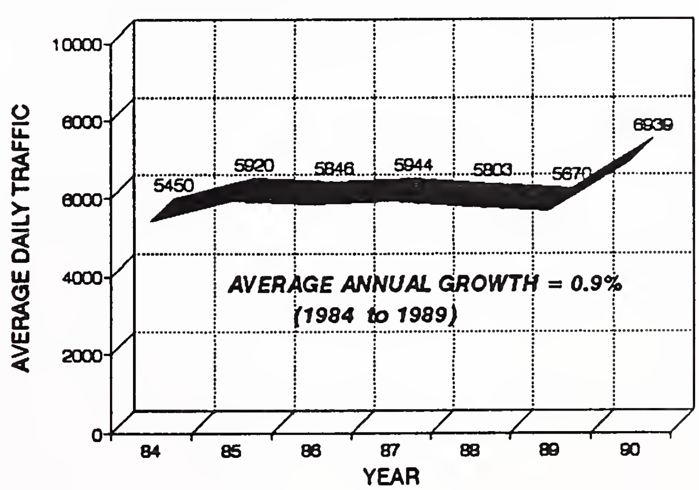
Historical Factors

Data provided by the City of Billings indicated that traffic volumes on city streets have remained fairly constant over the past four years. Within the past year traffic volumes have begun to increase at a number of locations. MDoT's permanent count stations provided the most reliable indication of traffic growth in the urban area, historically. Data from those stations provides general, long range trends in traffic growth. Figure 2., below, illustrates traffic growth on north-south and east-west streets within the past seven to ten years. Generally, traffic is growing at an annual rate of approximately 0.7 to 0.9 percent.

HISTORIC TRAFFIC GROWTH
BROADWATER AVE (ARTERIAL)



HISTORIC TRAFFIC GROWTH
19TH STREET W (COLLECTOR)

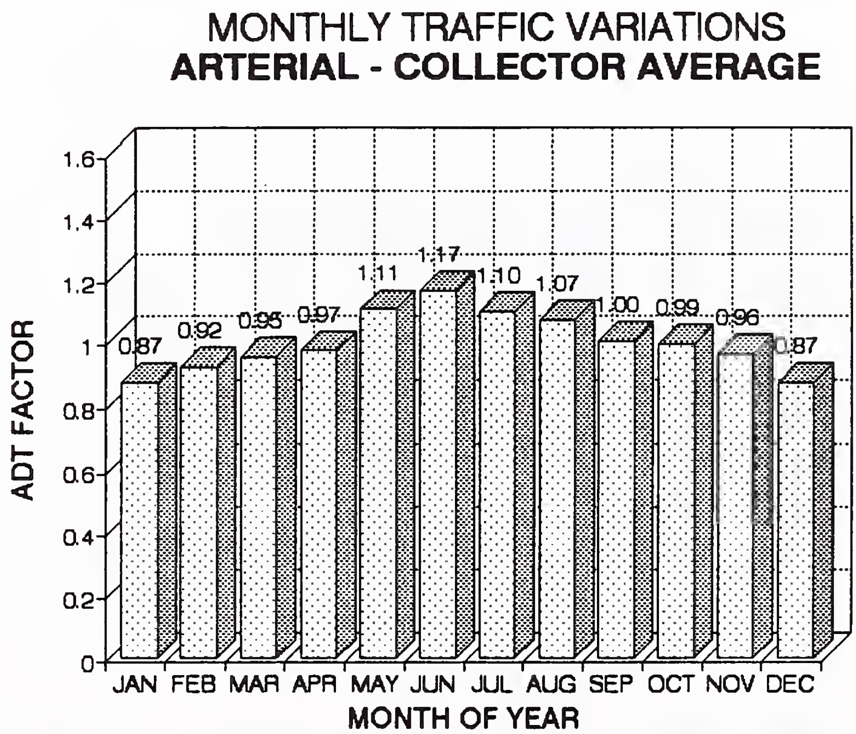


Monthly Variations

A key factor in estimating average daily traffic is the month of the year. Traffic tends to vary significantly depending on the weather, seasonal economy, school sessions and various other reasons. Monthly variations provide an accurate reflection of seasonal conditions.

Figure 3. illustrates monthly traffic variations for arterials and collector streets in Billings. This data is an average of all permanent count stations within the City Limits and was extracted from MDoT's permanent count station records.

There is very little difference between the monthly variation at each individual count station which indicates that seasonal variations are fairly homogeneous throughout the city's major street system.



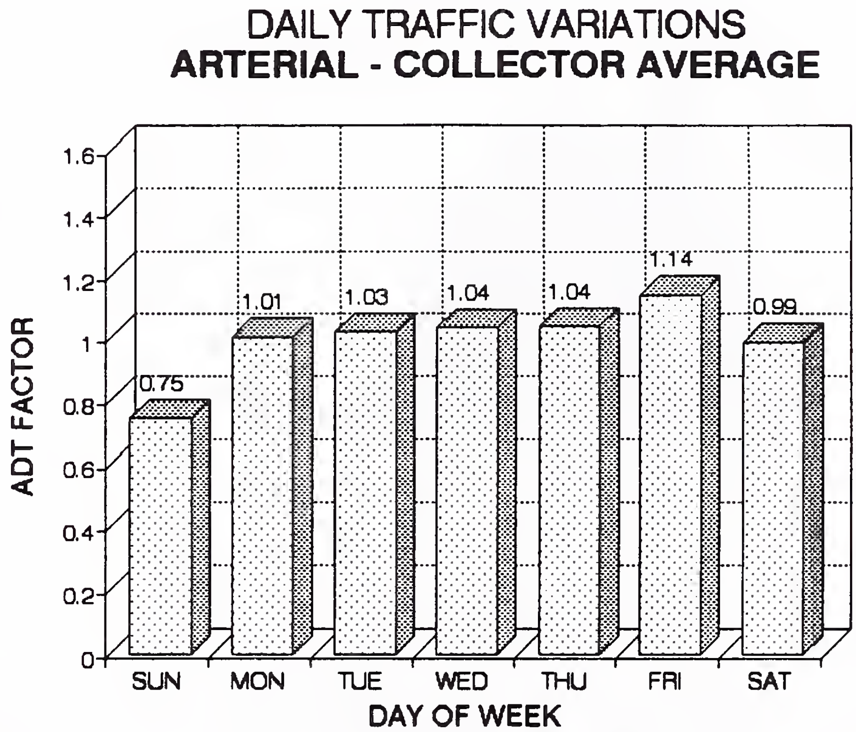
June is the highest volume month, with approximately 117% of the average monthly traffic. January and December are the lowest traffic months with ADT's being about 87% of the average month.

Daily Variations

Traffic volumes vary significantly according to the day of the week and play an important role in estimating average daily traffic. Factors derived from extended traffic counts are not usually as reliable as monthly or seasonal factors due to the smaller time frame. Special holidays and events tend to skew daily variations. As an example, Monday holidays tend to have lower traffic than normal while the following Tuesday has higher than normal traffic.

Figure 4., right illustrates daily traffic variations in Billings. This data was again extracted from MDoT's permanent count stations.

There appears to be some differences in daily variation between count stations due to the type of traffic served. However those differences are not considered significant.

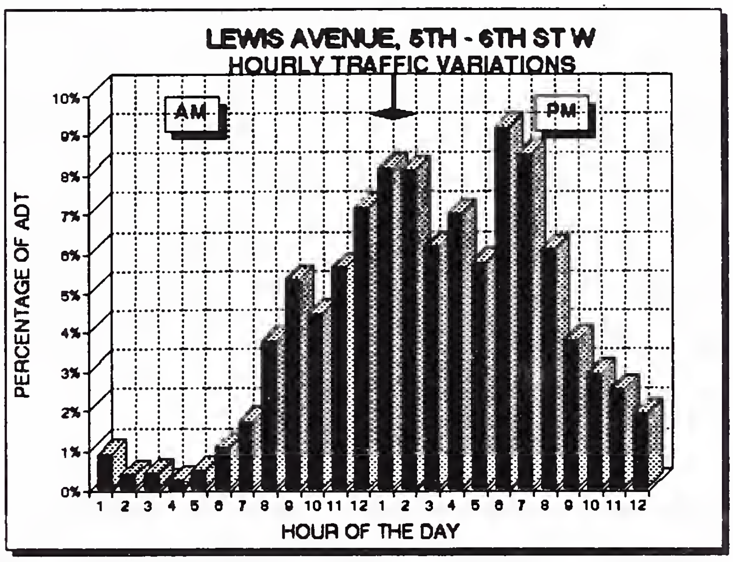


The highest traffic day of the week is Friday, with 114% of average daily traffic. The lowest traffic day is Sunday, with only 75% of ADT. The remaining weekdays are fairly consistent at 101 to 104% of ADT. Interestingly, Mondays have the lowest percentage of ADT while data from a decade ago indicated that Mondays were the second highest traffic day of the week. There have obviously been some sort of social or economic changes that have occurred in the past 10 to 15 years to cause this degree of difference.

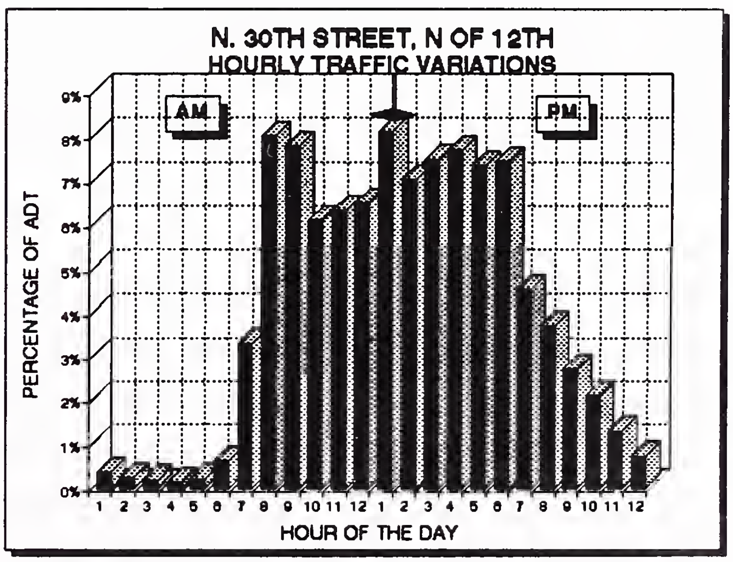
Hourly Variations

Variations in traffic volumes by time of the day is highly predictable since there is usually no significant differences from one weekday to the next, at any one location. However, differences between various types of streets and locations can be vastly dissimilar. Twenty four hour machine recording counts on the same or similar streets are necessary to accurately estimate ADT's from shorter period counts.

Figure 5., right, presents hourly traffic variations on N. 30th Street and on Lewis Ave. These are only two of numerous hourly count summaries prepared from data provided by the City of Billings and City-County Planning.



Both graphs have different shapes. N. 30th is primarily used as an inbound commuter route, thus the morning peak exceeds the afternoon peak.



Lewis Avenue has a predominant outbound traffic pattern and this can be seen in the high evening peak.

Street Characteristics - The Billings city street system is laid out on a grid system with two separate orientations. The original townsite grid system runs parallel and perpendicular to the railroad which is on a northeast by southwest bearing. Newer sections within the City run north and south. This along with physical barriers (the Rimrocks and the Yellowstone River) have caused a street system evolution which presents high concentrations of traffic on some arterial streets and interesting geometry at certain intersections. Through the years, after establishment of the original townsite, subdivision development was patterned around the imposing-physical constraints, which resulted in a number of continuous east-west streets suitable for arterial status. Unfortunately, land developments also blocked continuity of streets in the north-south directions. At present, there is only one continuous north-south arterial traversing the Billings urban area. Consequently, north-south traffic is dispersed among a number arterial, collector and local streets. Some of the accident sites within this study are located on streets which carry spill-over north-south traffic volumes.

Physical characteristics of the streets are typical of most western cities. There is a mixture of old and new roadway design standards and access control. Because of a successful pavement management program instituted in Billings approximately seven years ago, the majority of street surfaces could be classed in a good to excellent category. In only a few cases are the street surfaces less than ideal at the study sites. In only one case is accident experience directly related to uneven street surfaces.

A common problem observed at the study sites, involved lack of parking controls near intersections. While many of the sites have signs and and yellow curb marks most of the local residential streets do not. This is entirely understandable, since it is very costly to mark every intersection when 90% of the time there are no apparent problems. Even when an accident problem surfaces, it is very difficult to attribute it to a mobile sight restriction. Only when changes in traffic volumes or parking habits occur do accident problems start to surface.

Another common observation at local intersections was the roadside environment relating to trees, hedges and fences within in the intersection sight triangle. While the City of Billings does an excellent job of keeping trees trimmed, tree trunks in the boulevard areas are so large that they sometimes create an intermittent sight restriction which may or may not be related to some of the angle accidents. These type of blind spots can sometimes be more hazardous than a large imposing sight restriction because motorists are not consciously aware of the brief loss of sight.

Traffic Control Devices - Some degree of traffic control devices were present at almost all of the sites. The applications range from street name signs to traffic signals. Most of the signs and markings were applied correctly according to the Manual on Uniform Traffic Control Devices (MUTCD). Street signs appear to be in good condition at almost all of the sites. One of the most positive aspects of the Cities' signage was positive guidance on the street system. All study locations had street name signs mounted in consistent locations. Lack of such signing can become a major safety problem for motorists not familiar with Billings. In this situation, a large portion of the drivers cognitive powers are directed toward navigation. When there is little positive guidance provided, critical driving mistakes can be committed because little conscious ability remains for the other varied driving tasks.

Some damaged and faded signs were noted throughout the city. While not a very large percentage of total signs fall into that category, it is important to replace signs which become ineffective. The City of Billings has been developing a complete sign inventory and management system. Through this system, signs are replaced on a priority basis as budget allows. It is recommended that the City develop a program which allows all signs, regardless of priority, to be replaced after a maximum period of time in the sign's life.

There are numerous traffic signal installations within the City of Billings. Most of those signals are on the Federal Aid System and some, including two within the confines of this study, are exclusively within the city's jurisdiction. While several problems could be cited with some of the On-system signal installations, there are

only a few minor problems with the City's signals that can be noted. Most of these problem are directly related to the age of the systems involved. Numbers and sizes of signal heads are not consistent between similar intersections and some pole locations are not ideal. Considering the vast improvements in signal upgrade work that has been completed in Billings in the past four to five years, it is only a matter of time before all of the Cities' signal become current with new standards and state-of-the-art equipment.

Traffic Accidents

Traffic accident characteristics for all of the Billings study sites are summarized below:

Category	Total	Average Per Site
Total Number of Sites	25	NA
Total Number of Accidents	342	13.7
Study Period in Years	3.33	3.33
Traffic Volumes Entering	NA	7732
Accident Rate /MVE	NA	2.45
No. of Injuries	80	3.20
No. of Fatalities	0	0
Severity in 1000's $	1442	57.68
No. Angle Accidents	207	8.28
No. Rear End Accidents	57	2.28
No. Sideswipe Accidents	16	0.64
No. Pedestrian Accidents	4	0.16
No. Single Vehicle Accidents	9	0.36
No. Left turn Accidents	9	0.36
No. Parked Car Accidents	28	1.12
No. of Other Type Accidents	12	0.48

Of all the years in this period, 1988 had the least number of accidents (88), while 1990 had the most with 121. If 1991 accident statistics were projected from the first four months of the year, the number of accidents for the entire year would be

approximately 130 accidents, or slightly higher than 1989. The predominant trend appears to be increasing accidents at the study sites (18% per year). Angle accidents were the most common accident type, which accounts for the relatively high number of injuries. Most of the accidents occurred in clear weather on dry roads. night time accidents were not as common as daytime accidents. No fatal accidents occurred within the study sites. The average accident rate per site of 2.45/mve is higher than the typical intersection, as would be expected.

Future System Characteristics - Billings has an approved transportation plan which outlines certain transportation improvement projects to be constructed within the next twenty years. None of the short term improvements recommended within this report will have any significant effect on the implementation of long range transportation project. Some of the study sites provide short term solutions to problems which would be better served by more capital intensive long range projects or by projects having more far reaching effects than those served by short term improvements. Specific long range recommendations are made in the site specific sections of this report when applicable.

STUDY METHODOLOGY

The study was segregated into four distinct phases which best achieved the purpose and scope of the traffic study. These phases are outlined as follows:

Phase 1, Site Selection - involved copying all of the accident reports on Billings city streets for the years 1988 thru April of 1991 from Department of Justice files in Helena, Montana. City Police printouts and summaries in the City Traffic Engineer's office were also used to develop a preliminary listing of potential study sites. The state reports were sorted and arranged by Avenues and Streets and then cross referenced by intersection. On-system sites were discarded in the process. The reports were then screened for locations having 5 or more accidents during the reporting period. The State reports and city files were cross checked and some significant discrepancies were noted. Cross referenced accidents were confirmed and then entered into a computer program to calculate preliminary hazard index values.

Number of accidents, accident rates and severity indexes were calculated for fifty two cluster sites. Table 2 is a summary of the screening program. The cluster sites were ranked according to the composite value of the three indexes. A recommended list of sites was given to H. Terry Smith, City Traffic Engineer, City of Billings, for his review and approval. The list was modified due to current and local knowledge of projects in progress and projects that had recently been completed. After undesirable sites had been eliminated, the final list of sites was approved.

TABLE 2. CITY OF BILLINGS - ACCIDENT SITE SCREENING LIST
RANKING BY COMPOSITE ACCIDENT FACTOR

SITE RANK NO.	AVENUE or STREET	INTERSECTING STREET OR AVENUE	ACCIDENTS / YEAR 88	89	90	91	TOTAL NO. ACC.	NO. ACC. INDEX	APPROX. VOLUME	ACC. RATE	ACC. RATE INDEX	SVRTY INDEX	COMPOSITE SCREEN INDEX	REMARKS
1	AVENUE B	19TH STREET W	3	3	5	2	13	74	2500	4.27	74	44	63.7	OK
2	FOURTH AVENUE S	S 39TH STREET	3	1	2	2	8	81	1500	4.38	75	45	81.0	OK
3	SECOND AVENUE N	N 31ST STREET	7	6	5	4	22	87	5800	3.12	59	41	60.8	OK
4	THIRD AVENUE N	N 31ST STREET	5	3	8	4	20	85	6500	2.53	50	39	56.3	OK
5	SECOND AVE S	S 39TH STREET	3	3	0	1	7	58	1800	3.20	60	46	54.7	OK
6	THIRD AVENUE N	N 23RD STREET	4	3	5	0	12	72	4200	2.36	47	46	54.3	OK
7	ELEVENTH AVENUE N	N 31ST STREET	1	4	3	1	9	64	2800	2.64	52	48	54.0	OK
8	TENTH AVENUE N	N 31ST STREET	0	2	8	0	6	61	2000	3.28	61	38	53.4	OK
9	TWELFTH AVENUE N	N 30TH STREET	4	2	6	6	18	82	8000	1.85	39	46	53.4	OK
10	YELLOWSTONE AVENUE	1ST STREET W	3	3	4	0	10	67	2500	3.29	81	28	51.9	OK
11	HOWARD AVENUE	10TH STREET W	3	1	2	2	8	81	2200	2.99	57	38	51.8	OK
12	LEWIS AVENUE	6TH STREET W	2	5	7	1	15	78	6600	1.87	39	38	49.7	OK
13	ALDERSON AVENUE	3RD STREET W	2	2	5	0	9	64	3500	2.11	43	43	49.1	OK
14	PARKHILL DRIVE	13TH STREET W	2	6	6	2	18	82	10700	1.38	31	40	48.2	OK
15	POLY DRIVE	VIRGINIA LANE	6	7	5	2	20	85	11500	1.43	32	36	48.1	JURISDICTION ?
18	POLY DRIVE	13TH STREET W	7	3	2	5	17	61	12000	1.16	27	44	47.5	OK
17	TWELFTH AVENUE N	N 28TH STREET	3	3	5	1	12	72	4500	2.19	45	28	48.9	OK
16	SEVENTH AVENUE N	N 28TH STREET	0	2	2	5	9	64	4500	1.64	35	43	46.0	OK
19	HOWARD AVENUE	11TH STREET W	2	0	2	0	4	45	2000	1.64	35	54	44.4	OK
20	MONAD ROAD	20TH STREET W	5	3	8	1	15	78	14000	0.88	21	42	43.8	NEW PROJECT
21	SECOND AVENUE N	N 28TH STREET	3	8	3	1	15	78	14000	0.88	21	42	43.8	OK
22	THIRD AVENUE N	N 25TH STREET	2	8	5	1	14	76	9000	1.28	29	34	43.8	OK
23	LEWIS AVENUE	1ST STREET W	2	2	3	0	7	58	6200	0.93	22	56	43.4	OK
24	LEWIS AVENUE	8TH STREET W	3	2	7	1	13	74	12500	0.85	20	44	43.0	OK
25	LEWIS AVENUE	19TH STREET W	2	3	7	2	14	76	10000	1.15	26	34	42.6	OK
26	FOURTH AVENUE S	S 28TH STREET	4	2	0	0	6	54	3000	1.64	35	42	42.6	DECLINE
27	SECOND AVENUE N	N 24TH STREET	2	3	3	2	10	87	6000	1.37	31	36	42.8	OK
28	TENTH AVENUE N	N 30TH STREET	5	2	2	0	9	64	8000	0.92	22	48	42.4	DECREASE
29	ELEVENTH AVENUE N	N 30TH STREET	1	3	2	4	10	67	8000	1.03	24	42	41.9	ALTERNATE
30	THIRD AVENUE N	N 28TH STREET	5	3	2	2	12	72	14000	0.70	17	45	41.5	ALTERNATE
31	LEWIS AVENUE	10TH STREET W	0	1	3	2	6	54	6000	0.82	20	54	40.8	ALTERNATE
32	WYOMING AVENUE	1ST STREET W	0	1	4	1	6	54	3500	1.41	31	40	40.7	ALTERNATE
33	POLY DRIVE	WOODY DRIVE	3	1	1	0	5	50	5000	0.82	20	57	40.7	SINGLE YEAR
34	THIRD AVENUE N	N 14TH STREET	2	2	4	0	8	81	4000	1.64	35	28	40.3	ALTERNATE
35	COOK AVENUE	11TH STREET W	0	0	2	2	4	45	2200	1.49	33	45	40.2	INCREASING
36	THIRD AVENUE N	N 29TH STREET	6	2	0	0	6	61	9500	0.69	17	50	40.2	
37	ST. JOHNS AVENUE	21ST STREET W	0	3	2	1	8	54	5000	0.99	23	46	40.1	
38	THIRD AVENUE N	N 15TH STREET	1	2	2	1	6	54	5000	0.99	23	48	40.1	
39	SECOND AVENUE N	N 30TH STREET	4	1	3	1	9	64	7200	1.03	24	38	40.0	
40	THIRD AVENUE N	N 32ND STREET	3	0	3	2	8	81	6000	1.10	25	38	39.5	
41	POLY DRIVE	REHBERG LANE	4	4	3	0	11	69	7800	1.16	27	28	39.1	STATE PROJECT
42	THIRD AVENUE N	N 30TH STREET	1	4	3	0	8	61	6800	0.97	23	38	38.5	
43	TENTH AVENUE N	N 28TH STREET	3	2	1	0	6	54	4500	1.10	25	40	38.4	DECREASE
44	ST. JOHNS AVENUE	6TH STREET W	1	1	1	1	4	45	8000	0.41	11	61	37.2	
45	MONAD ROAD	19TH STREET W	1	0	4	1	8	54	14000	0.35	9	54	36.7	NEW PROJECT
46	SECOND AVENUE N	N 25TH STREET	1	0	4	0	5	50	7200	0.57	14	51	36.4	SINGLE YEAR
47	LAKE ELMO ROAD	JOSEPHINE STREET	1	1	5	0	7	58	5000	1.15	26	28	35.9	SINGLE YEAR
46	EIGHT AVENUE N	N 29TH STREET	0	5	1	0	6	54	4000	1.23	28	28	35.5	SINGLE YEAR
49	ROOSVELT AVENUE	JACKSON STREET	0	0	3	0	3	40	3000	0.82	20	48	34.6	SINGLE YEAR
50	LEWIS AVENUE	17TH STREET W	5	1	2	0	8	61	9500	0.69	17	28	33.2	SINGLE YEAR
51	THIRD AVENUE N	N 19TH STREET	0	2	2	1	5	50	4000	1.03	24	28	32.6	
52	WYOMING AVENUE	15TH STREET W	1	0	2	3	6	54	9000	0.55	14	28	30.0	INCREASING
		TOTALS =	122	120	154	63	459							
		AVE. YEAR =	2.6	2.6	3.6	1.4	10.8	66.3	6332.6	1.7	35.3	42.0	46.2	

NOTE: 1991 Accidents only include the months of January thru April

Composite Index: Number Accidents = 28%, Accident Rate = 39%, Severity = 33%

Phase 2, Data Collection - included preliminary organization of the project including scheduling, site location, form processing, field data collection and reduction of data. Accident data was obtained from reports provided by the Department of Justice. Traffic counts were taken at each location. The existing average daily traffic was determined by applying factors for hourly, daily and monthly variations. Other data collected in the field, included measurement of road widths and geometrics, and inventory of traffic control devices, turning movement counts and subjective observation of traffic operations. Engineering Inc. of Billings performed the field topo surveys, sign inventories and base sheet drafting.

Phase 3, Analysis of Data - included the determination of hazard indexes for each location by using the Federal Highway Administration Report *No. FHWA-RD-77-83 "Identification of Hazardous Locations".* Computations involved with accidents, volumes, capacities, indicator values and other aspects of hazard indexes were performed on a microcomputer using original templates for Ouattro Pro Ver. 3.0, developed by Marvin & Associates. Regression equations were developed to mathematically simulate hazard index curves contained in the FHA report. From these computations a preliminary hazard ranking list was prepared.

Phase 4, Evaluation of Corrective Measures - included the determination of improvements that would reduce or eliminate certain types of accidents or accidents in general at the study locations. Preliminary designs of those improvements included signing, geometric changes, and some minor reconstruction. The improvements were recommended on a short term basis. In most cases, the nature of the sites were such that long term improvements would not provide additional benefits beyond those expected through implementation of short term improvements.

Cost effectiveness calculations of the improvements at each location were determined by preparing preliminary cost estimates and computing economic benefits to arrive at a benefit/cost ratio. The method used to determine benefit/cost ratios is identical to that used by the Montana Department of Transportation Project Planning Section. All values used in the formulation were supplied by Hank Butzlaff, supervisor of that section. The composite hazard index ranking and benefit/cost ratio, then determined the final priority listing.

HAZARD INDEX ANALYSIS RESULTS

Seven hazard indexes were used as the preliminary basis of ranking hazardous sites. The following are brief descriptions of each index including data format, data collection, indicator scaling and site ranking with respect to each index.

1. **Number of Accidents** - This indicator provides a historical background of accidents at the investigation site. In the case of Billings, a three year, four month period was used, which included 1988 - April 1991. The accident reports were photo copied in Helena and provided to the consultant. The data represents all reports filed within the city limits of Billings.

Figure 6. is a curve extracted from the FHWA report which was used to determine the indicator value. The data base is number of accidents per year. This indicator, as all of the seven indicators used in the report, is scaled between 0 and 100. An average of two accidents per year in a three year period indicates a hazardous location (indicator value of 33). An average of ten accidents per year is used to designate a very hazardous location (indicator value of 67). In the case of this study, the total number of accidents per site criteria was used to extract the index value rather than the annual rate. This higher value is therefore more consistent with the level of the other index values. Using an annual rate would have scaled down the importance of this indicator relative to other index values. Table 3. is the computer generated ranking of all sites based on this indicator. It can be seen that none of the sites exceeded the maximum value of 100 and the average value was in the same range as other hazard index values.

2. **Accident Rate Indicator** - This indicator somewhat compensates for any incomplete information provided by the number of accident indicator in that an exposure value is provided by the relationship between accidents and the total volume of vehicles using the facility. This indicator is expressed as the number of accidents per million entering vehicles. In the case of an intersection, "million entering vehicles" is the sum of the daily average approach volumes on all legs of the intersection, multiplied by the number of days in the analysis period.

TABLE 3. SITE RANKING BY NUMBER OF ACCIDENTS

RANK NO.	AVENUE	STREET	ACCIDENTS / YEAR 88	89	90	91	TOTAL NO. ACC.	NO. ACC. INDEX
1	THIRD AVENUE N	N 31ST STREET	5	6	9	4	24	90
2	POLY DRIVE	13TH STREET W	10	4	3	5	22	87
3	SECOND AVENUE N	N 31ST STREET	7	6	6	3	22	87
4	POLY DRIVE	VIRGINIA LANE	6	7	5	2	20	85
5	PARKHILL DRIVE	13TH STREET W	2	5	10	1	18	82
6	TWELFTH AVENUE N	N 30TH STREET	4	2	6	6	18	82
7	LEWIS AVENUE	6TH STREET W	2	5	8	1	16	79
8	SECOND AVENUE N	N 28TH STREET	5	9	1	1	16	79
9	LEWIS AVENUE	19TH STREET W	2	3	8	2	15	78
10	THIRD AVENUE N	N 23RD STREET	5	5	5	0	15	78
11	AVENUE B	19TH STREET W	3	3	6	2	14	76
12	LEWIS AVENUE	8TH STREET W	3	4	6	1	14	76
13	THIRD AVENUE N	N 25TH STREET	2	6	5	1	14	76
14	YELLOWSTONE AVEN	1ST STREET W	5	3	5	0	13	74
15	ELEVENTH AVENUE N	N 30TH STREET	2	3	3	4	12	72
16	TENTH AVENUE N	N 31ST STREET	2	2	8	0	12	72
17	HOWARD AVENUE	10TH STREET W	4	2	3	2	11	69
18	ALDERSON AVENUE	3RD STREET W	2	2	6	0	10	67
19	LEWIS AVENUE	1ST STREET W	4	2	4	0	10	67
20	SECOND AVENUE N	N 24TH STREET	2	3	2	3	10	67
21	WYOMING AVENUE	1ST STREET W	2	2	5	1	10	67
22	FOURTH AVENUE S	S 39TH STREET	3	1	2	2	8	61
23	SECOND AVE S	S 39TH STREET	3	3	1	1	8	61
24	HOWARD AVENUE	11TH STREET W	2	1	2	0	5	50
25	LEWIS AVENUE	10TH STREET W	1	1	2	1	5	50
		TOTALS =	88	90	121	43	342	
		AVERAGES =	3.5	3.6	4.8	1.7	13.7	73.2

NOTE: 1991 DATA ONLY INCLUDES JANUARY THRU APRIL

The accident rate indicator is a very important part of the hazard index ranking method and data collection is possible when a continued program of traffic counting has been performed. Spot counts adjusted by yearly volume increases, seasonal variations, daily variations and hourly variations were necessary at most of the sites to develop an average daily traffic figure applied to the analysis period.

Figure 7 represents the graphic plot of accident rate versus indicator value. As before, the indicator value ranges between 0 and 100. Table 4 is the computer generated ranking of sites based on this indicator. It can be seen that the intersections included in this study were not high traffic volume locations in Billings, since the average rate index was below 50.

3. Accident Severity Indicator - Although there are many factors involved in the severity of accidents, statistical studies over a significant number of years have given fairly reliable dollar values in terms of economic loss for each type of accident. The accident severity indicator correlates a probable cause and effect relationship which aids in the determination of the level of accident reduction measures required. Severity values can also be used as a determinant of benefits resulting from various improvements. The data base for accident severity is average relative severity in thousands of dollars. Data collection necessary for the use of the severity index is made possible by the accident report form. Dollar values for severity were provided by Hank Butzlaff of the Montana Department of Transportation. They are: Fatal Accident = $500,000, Injury Accident = $11,000 and Property Damage Accident = $2,000. Recently, the method of calculating fatal and injury costs was changed by MDoT to include total number of persons injured or killed rather than just an injury or fatal accident as a single incident. In the case of this study, some single accidents produced multiple injuries which increased the relative severity of those sites significantly.

The FHWA report presents the relative severity index values for each type of accident. Once the type of accident has been established, Figure 8 enables the user to assess the indicator value. Figure 8 is a graphic plot of the average severity in thousands of dollars versus the indicator value which is based on a scale of 0 to 100. Table 5 is the computer generated ranking of sites based on this indicator.

TABLE 4. SITE RANKING BY ACCIDENT RATE

RANK NO.	AVENUE	STREET	NO. ACC. 3.33 YEARS	1991 ADT	ADT PERIOD AVE.	AC. RATE (MVE)	ACC RATE IND VALUE
1	HOWARD AVENUE	10TH STREET W	11	1300	1300	7.32	100
2	TENTH AVENUE N	N 31ST STREET	12	1700	1700	6.11	93
3	YELLOWSTONE AVENUE	1ST STREET W	13	1900	1900	5.92	91
4	WYOMING AVENUE	1ST STREET W	10	2300	2300	3.76	67
5	FOURTH AVENUE S	S 39TH STREET	8	1900	1900	3.64	66
6	SECOND AVE S	S 39TH STREET	8	2100	2100	3.30	61
7	AVENUE B	19TH STREET W	14	3600	3500	3.29	61
8	THIRD AVENUE N	N 23RD STREET	15	4500	4400	2.95	56
9	HOWARD AVENUE	11TH STREET W	5	1700	1700	2.54	50
10	ALDERSON AVENUE	3RD STREET W	10	3700	3600	2.40	48
11	SECOND AVENUE N	N 31ST STREET	22	8100	8000	2.38	48
12	TWELFTH AVENUE N	N 30TH STREET	18	7900	7800	2.00	41
13	THIRD AVENUE N	N 25TH STREET	14	6800	6700	1.81	38
14	THIRD AVENUE N	N 31ST STREET	24	11900	11600	1.79	38
15	SECOND AVENUE N	N 24TH STREET	10	5300	5200	1.66	36
16	LEWIS AVENUE	6TH STREET W	16	9600	9300	1.49	33
17	PARKHILL DRIVE	13TH STREET W	18	11300	11000	1.42	31
18	ELEVENTH AVENUE N	N 30TH STREET	12	8400	8200	1.27	29
19	LEWIS AVENUE	19TH STREET W	15	11000	10800	1.20	27
20	POLY DRIVE	13TH STREET W	22	16600	16200	1.17	27
21	LEWIS AVENUE	1ST STREET W	10	9100	8900	0.97	23
22	LEWIS AVENUE	8TH STREET W	14	14100	13800	0.88	21
23	POLY DRIVE	VIRGINIA LANE	20	20600	20100	0.86	21
24	SECOND AVENUE N	N 28TH STREET	16	16800	16500	0.84	20
25	LEWIS AVENUE	10TH STREET W	5	11100	10800	0.40	11
		AVERAGE VALUES =	14	7732	7572	2.45	45

TABLE 5. SITE RANKING BY ACCIDENT SEVERITY

RANK NO.	AVENUES	STREETS	SUM OF SEVERITY VALUES	TOTAL NO. ACC.	AVERAGE SEVERITY INDEX	INDICATOR VALUE
1	HOWARD AVENUE	11TH STREET W	$59,000	5	$11,800	69
2	SECOND AVENUE N	N 28TH STREET	$121,000	16	$7,563	58
3	FOURTH AVENUE S	S 39TH STREET	$45,000	8	$5,625	51
4	LEWIS AVENUE	1ST STREET W	$56,000	10	$5,600	51
5	ALDERSON AVENUE	3RD STREET W	$49,000	10	$4,900	49
6	AVENUE B	19TH STREET W	$68,000	14	$4,857	49
7	PARKHILL DRIVE	13TH STREET W	$85,000	18	$4,722	48
8	LEWIS AVENUE	8TH STREET W	$66,000	14	$4,714	48
9	LEWIS AVENUE	6TH STREET W	$72,000	16	$4,500	47
10	THIRD AVENUE N	N 31ST STREET	$108,000	24	$4,500	47
11	TWELFTH AVENUE N	N 30TH STREET	$81,000	18	$4,500	47
12	ELEVENTH AVENUE N	N 30TH STREET	$51,000	12	$4,250	46
13	SECOND AVE S	S 39TH STREET	$34,000	8	$4,250	46
14	SECOND AVENUE N	N 24TH STREET	$40,000	10	$4,000	45
15	LEWIS AVENUE	10TH STREET W	$19,000	5	$3,800	44
16	THIRD AVENUE N	N 23RD STREET	$57,000	15	$3,800	44
17	HOWARD AVENUE	10TH STREET W	$40,000	11	$3,636	43
18	SECOND AVENUE N	N 31ST STREET	$80,000	22	$3,636	43
19	POLY DRIVE	VIRGINIA LANE	$67,000	20	$3,350	42
20	THIRD AVENUE N	N 25TH STREET	$46,000	14	$3,286	42
21	POLY DRIVE	13TH STREET W	$71,000	22	$3,227	41
22	WYOMING AVENUE	1ST STREET W	$29,000	10	$2,900	40
23	TENTH AVENUE N	N 31ST STREET	$33,000	12	$2,750	39
24	LEWIS AVENUE	19TH STREET W	$39,000	15	$2,600	38
25	YELLOWSTONE AVEN	1ST STREET W	$26,000	13	$2,000	34
		TOTAL SEVERITY $ =	$1,442,000			
		TOTAL NO. ACC. =		342		
		AVE. SEVERITY / ACC. =			$4,216	
		AVE. IND. VAL / SITE =				46

4. **Volume to Capacity Ratio Indicator** - This indicator not only reflects exposure rates but also incorporates existing street geometry, access and conditions such as traffic type, turning directions, volume mix and number of lanes. Computation of the volume capacity indicator is expressed as follows:

V/C = ADT/24 HOUR CAPACITY

Modifications to the basic V/C formula were felt necessary because of the predominance of intersections within this study and the vast changes that have occurred in capacity theory since the time when the FHWA report was published. Use of the original formula would have diluted the relative importance of this indicator if calculated in this manner. Therefore, volume/capacity calculation using the 1985 Highway Capacity Manual procedures were used and expressed as a peak hour V/C. If the above formula were used, the maximum index value would have been 70 and half of the sites would have had an indicator value less than 10.

Data required for the volume capacity ratio involved field measurements of existing geometrics, turning counts and volume mix. The capacity of each intersection is computed through methodology presented in the 1985 *Highway Capacity Manual* using FHWA computer software. Although this indicator is cumbersome to use by inexperienced personnel, its inclusion is considered necessary and correlates well in hazardous index ranking.

Figure 9. presents a graphic plot of the volume capacity ratio versus the indicator value which is also scaled between 0 and 100. Table 6. is the computer generated ranking of the sites based on this indicator. The average value for this indicator was 42 while values ranged between 9 and 100.

TABLE 6. SITE RANKING BY VOLUME/CAPACITY

RANK NO.	AVENUES	STREETS	PEAK HOUR CAPACI	PEAK HOUR FLOW	* V/C RATIO	V/C INDICATOR VALUE
1	LEWIS AVENUE	8TH STREET W	235	277	1.18	100
2	POLY DRIVE	VIRGINIA LANE	**	**	0.84	100
3	PARKHILL DRIVE	13TH STREET W	295	189	0.64	91
4	LEWIS AVENUE	19TH STREET W	**	**	0.60	87
5	SECOND AVENUE N	N 28TH STREET	**	**	0.43	69
6	POLY DRIVE	13TH STREET W	**	**	0.37	63
7	LEWIS AVENUE	1ST STREET W	365	124	0.34	59
8	TWELFTH AVENUE N	N 30TH STREET	510	167	0.33	57
9	LEWIS AVENUE	6TH STREET W	433	115	0.27	50
10	THIRD AVENUE N	N 25TH STREET	1130	277	0.25	47
11	ELEVENTH AVENUE N	N 30TH STREET	503	104	0.21	42
12	WYOMING AVENUE	1ST STREET W	905	134	0.15	33
13	THIRD AVENUE N	N 31ST STREET	1446	214	0.15	33
14	LEWIS AVENUE	10TH STREET W	284	40	0.14	32
15	SECOND AVENUE N	N 31ST STREET	1663	206	0.12	29
16	SECOND AVENUE N	N 24TH STREET	489	57	0.12	28
17	THIRD AVENUE N	N 23RD STREET	729	55	0.08	21
18	AVENUE B	19TH STREET W	853	58	0.07	19
19	YELLOWSTONE AVENU	1ST STREET W	887	53	0.06	17
20	TENTH AVENUE N	N 31ST STREET	967	56	0.06	17
21	FOURTH AVENUE S	S 39TH STREET	968	56	0.06	17
22	SECOND AVE S	S 39TH STREET	903	34	0.04	13
23	ALDERSON AVENUE	3RD STREET W	763	26	0.03	12
24	HOWARD AVENUE	11TH STREET W	953	30	0.03	11
25	HOWARD AVENUE	10TH STREET W	979	24	0.02	9
	AVERAGE VALUES		650	92	0.26	42

* V/C Refers to capacity of the minor street in the case of uncontrolled or stop/yeild controlled intersections.

** V/C Refers to average v/c for all legs of signalized intersection or a four way stop intersection.

5. **Sight Distance Indicator** - This indicator is of significant value in both rural and urban locations, especially at intersections. Even though the weighting factor in the hazard index computation is low, it is still considered valuable in determining cause and effect relationships and other deficiencies at the accident cluster sites.

The data format for using the sight distance indicator is the ratio of actual sight distance to desirable sight distance. The FHWA report presents the minimum stopping sight distance on wet pavement for the various design speeds. Actual stopping sight distance is the distance from the drivers position to the point where a stop may be required to avoid a hazardous maneuver or direct collision. Required sight distances vary according to the type of control encountered. At uncontrolled intersections specific AASHTO guidelines for this situation are used. At stop controlled and signalized intersections two different requirements are applied: 1. stopping sight distance to the control device & 2. intersection sight distance required to cross the intersection. The various required sight distances and measured values are computed and combined according to the study method's formulation to determine the indicator value.

The data format for this indicator is the sight distance ratio of actual over desirable. Collection of the sight distance data requires field measurements of sight distance and determination of average travel speeds. Figure 10. presents a graphic plot of the sight distance ratio versus the indicator value which ranges from 0 to 100. Table 7. is the computer generated ranking of sites based on this indicator. A total of 9 sites had indicator values of 100 and they ranged down to 9. Considering all of the possible restrictions present in an urban environment, the higher values should not be unexpected.

TABLE 7. SITE RANKING BY SIGHT DISTANCE

RANK NO.	INTERSECTION LOCATION		APP1 SD	REQ SD	RATIO	APP2 SD	REQ SD	RATIO	APP3 SD	REQ SD	RATIO	APP4 SD	REQ SD	RATIO	*WT. IND VAL
1	THIRD AVENUE N	N 31ST STREET	160	200	0.80	90	350	0.26	160	350	0.46	300	200	1.50	100
2	SECOND AVENUE N	N 24TH STREET	150	200	0.75	150	200	0.75	100	350	0.29	150	300	0.50	100
3	ELEVENTH AVENUE N	N 30TH STREET	200	200	1.00	200	200	1.00	120	350	0.34	160	350	0.46	100
4	TWELFTH AVENUE N	N 30TH STREET	250	200	1.25	250	200	1.25	140	350	0.40	160	350	0.46	100
5	SECOND AVENUE N	N 31ST STREET	180	200	0.90	90	350	0.26	0	0	ERR	0	0	ERR	100
6	LEWIS AVENUE	1ST STREET W	100	200	0.50	300	200	1.50	300	350	0.86	160	350	0.46	100
7	LEWIS AVENUE	10TH STREET W	100	200	0.50	300	150	2.00	180	350	0.51	200	350	0.57	100
8	THIRD AVENUE N	N 23RD STREET	300	200	1.50	300	200	1.50	160	350	0.51	160	350	0.51	100
9	LEWIS AVENUE	6TH STREET W	150	200	0.75	150	220	0.68	150	300	0.50	160	300	0.60	100
10	PARKHILL DRIVE	13TH STREET W	200	200	1.00	120	200	0.60	220	400	0.55	220	400	0.55	93
11	THIRD AVENUE N	N 25TH STREET	300	200	1.50	140	350	0.40	0	0	ERR	0	0	ERR	58
12	LEWIS AVENUE	8TH STREET W	220	200	1.10	300	200	1.50	220	300	0.73	300	300	1.00	51
13	SECOND AVENUE N	N 28TH STREET	300	200	1.50	300	200	1.50	150	300	0.50	300	200	1.50	50
14	WYOMING AVENUE	1ST STREET W	110	130	0.85	130	130	1.00	130	130	1.00	120	130	0.92	46
15	HOWARD AVENUE	10TH STREET W	140	110	1.27	130	110	1.18	100	110	0.91	110	110	1.00	39
16	HOWARD AVENUE	11TH STREET W	120	110	1.09	120	110	1.09	100	110	0.91	130	110	1.18	37
17	POLY DRIVE	13TH STREET W	150	300	0.50	400	200	2.00	400	200	2.00	400	200	2.00	35
18	YELLOWSTONE AVENUE	1ST STREET W	180	130	1.38	130	130	1.00	140	130	1.08	170	130	1.31	33
19	TENTH AVENUE N	N 31ST STREET	110	110	1.00	120	110	1.09	140	110	1.27	120	110	1.09	32
20	ALDERSON AVENUE	3RD STREET W	170	130	1.31	150	130	1.15	160	130	1.23	130	130	1.00	31
21	POLY DRIVE	VIRGINIA LANE	400	200	2.00	400	200	2.00	400	200	2.00	160	275	0.58	31
22	AVENUE B	19TH STREET W	160	130	1.23	150	130	1.15	200	130	1.54	160	130	1.23	23
23	FOURTH AVENUE S	S 39TH STREET	170	110	1.55	140	110	1.27	140	110	1.27	130	110	1.18	21
24	SECOND AVE S	S 39TH STREET	180	110	1.64	160	110	1.45	150	110	1.36	160	110	1.45	13
25	LEWIS AVENUE	19TH STREET W	300	200	1.50	300	200	1.50	300	200	1.50	300	200	1.50	9
														AVERAGE INDICATOR VALUE =	60.1

* WEIGHTED INDICATOR VALUE IS CALCULATED BY THE FORMULA (2xHIGHVAL + 2ndHIGHVAL)/3

APP# SD's = MEASURED SIGHT DISTANCE ON DIRECTIONAL APPROACHES FOR VARIOUS CONDITIONS OF CONTROL

REQ SD = REQUIRED SIGHT DISTANCE ACCORDING TO AASHO

6. **Driver Expectancy Indicator** - This indicator relates human behavior factors to existing road conditions. The value of this indicator is realized in the fact that the roadway geometrics and roadside culture are evaluated on a human judgement basis.

The data format for the driver expectancy index is the problem rating scale. Being a subjective indicator, the degree of expectancy is rated on a scale from 1 to 6, and the expectancy rating varies linearly with the indicator value as shown in Figure 12. The expectancy rating form can be found in the FHWA report for further reference. Table 8. is the computer generated ranking of sites based on this indicator.

7. **Information System Deficiencies Indicator** - This indicator also provides a value or subjective judgement on the sufficiency of traffic control devices which transfer necessary information to the operator.

The data format for the information system deficiencies indicator is similar to that of the driver expectancy indicator in that a value form is used to provide a rating between 1 and 6. The rating for this indicator is also plotted linearly between the indicator range values of 0 and 100 and is shown on Figure 13. The value rating form is for the information system deficiencies indicator. It is also presented in the FHWA report for further reference. Table 9. is the computer generated ranking of sites based on this indicator.

TABLE 8. SITE RANKING BY DRIVER EXPECTANCY

RANK NO.	AVENUE	STREET	NB RATE	SB RATE	EB RATE	WB RATE	WGTD. RATE	IND VAL
1	LEWIS AVENUE	8TH STREET W	4	6	5	5	5.0	83
2	POLY DRIVE	VIRGINIA LANE	5	5	5	5	5.0	83
3	ELEVENTH AVENUE N	N 30TH STREET	4	5	5	5	4.8	79
4	PARKHILL DRIVE	13TH STREET W	5	5	4	4	4.5	75
5	LEWIS AVENUE	10TH STREET W	6	5	4	3	4.5	75
6	AVENUE B	19TH STREET W	5	6	3	4	4.5	75
7	THIRD AVENUE N	N 31ST STREET	4			5	4.5	75
8	LEWIS AVENUE	6TH STREET W	5	3	5	4	4.3	71
9	FOURTH AVENUE S	S 39TH STREET	5	6	3	3	4.3	71
10	ALDERSON AVENUE	3RD STREET W	6	5	3	3	4.3	71
11	WYOMING AVENUE	1ST STREET W	5	5	3	4	4.3	71
12	THIRD AVENUE N	N 25TH STREET	3			5	4.0	67
13	SECOND AVENUE N	N 28TH STREET	5	4	3		4.0	67
14	SECOND AVENUE N	N 31ST STREET	3		5		4.0	67
15	TWELFTH AVENUE N	N 30TH STREET	3	4	5	4	4.0	67
16	LEWIS AVENUE	1ST STREET W	5	5	2	2	3.5	58
17	TENTH AVENUE N	N 31ST STREET	3	3	4	4	3.5	58
18	YELLOWSTONE AVENUE	1ST STREET W	4	4	3	3	3.5	58
19	HOWARD AVENUE	11TH STREET W	4	4	3	3	3.5	58
20	LEWIS AVENUE	19TH STREET W	3	3	4	4	3.5	58
21	POLY DRIVE	13TH STREET W	3	3	4	3	3.3	54
22	HOWARD AVENUE	10TH STREET W	3	3	3	3	3.0	50
23	SECOND AVE S	S 39TH STREET	2	4	3	3	3.0	50
24	SECOND AVENUE N	N 24TH STREET	3	3	3		3.0	50
25	THIRD AVENUE N	N 23RD STREET	2	2		3	2.3	39
					AVERAGE INDICATOR VALUE =			65.2

TABLE 9. SITE RANKING BY INFORMATION DEFICIENCY

RANK NO.	AVENUES	STREETS	NB RATE	SB RATE	EB RATE	WB RATE	WGTD. RATE	IND VAL
1	AVENUE B	19TH STREET W	4	6	5	5	5.0	83
2	SECOND AVENUE N	N 31ST STREET	4		5		4.5	75
3	ALDERSON AVENUE	3RD STREET W	5	3	5	5	4.5	75
4	POLY DRIVE	VIRGINIA LANE	3	5	5	4	4.3	71
5	LEWIS AVENUE	10TH STREET W	6	5	3	3	4.3	71
6	PARKHILL DRIVE	13TH STREET W	5	5	3	3	4.0	67
7	SECOND AVENUE N	N 28TH STREET	5	4	3		4.0	67
8	WYOMING AVENUE	1ST STREET W	3	3	5	5	4.0	67
9	LEWIS AVENUE	19TH STREET W	4	4	4	4	4.0	67
10	LEWIS AVENUE	8TH STREET W	4	5	3	4	4.0	67
11	FOURTH AVENUE S	S 39TH STREET	5	5	3	3	4.0	67
12	TWELFTH AVENUE N	N 30TH STREET	3	4	4	4	3.8	63
13	ELEVENTH AVENUE N	N 30TH STREET	3	3	5	4	3.8	63
14	SECOND AVENUE N	N 24TH STREET	4	4	3		3.7	61
15	THIRD AVENUE N	N 25TH STREET	4			3	3.5	58
16	LEWIS AVENUE	1ST STREET W	5	5	2	2	3.5	58
17	THIRD AVENUE N	N 31ST STREET	3			4	3.5	58
18	POLY DRIVE	13TH STREET W	4	4	3	3	3.5	58
19	YELLOWSTONE AVENUE	1ST STREET W	3	3	4	4	3.5	58
20	LEWIS AVENUE	6TH STREET W	4	4	3	3	3.5	58
21	TENTH AVENUE N	N 31ST STREET	3	3	4	4	3.5	58
22	HOWARD AVENUE	11TH STREET W	3	3	4	4	3.5	58
23	HOWARD AVENUE	10TH STREET W	3	3	3	3	3.0	50
24	SECOND AVE S	S 39TH STREET	3	3	3	3	3.0	50
25	THIRD AVENUE N	N 23RD STREET	2	3		3	2.7	44
			AVERAGE INDICATOR VALUE =					62.9

HAZARD RANKING

Once all of the data had been collected and the indicator values computed, indicator values and necessary data were transferred to the hazard index computation matrix. Each indicator is weighted in accordance with the FHWA report. The weighting factors are fractional portions of unity. When all nine indicators established in FHWA report are used, the sum of weights is equal to one. In the case of Billings, two indicators were omitted, the Traffic Conflict Indicator and the Erratic Maneuvers Indicator. Their exclusion from the study was not felt to be any deterrent in the ranking of hazardous sites. The use of seven indicators provides an 88.6% confidence in strength of evaluation.

Based on the hazard analysis for each site, a matrix of indicator values and final hazard index ratings was constructed on a Quattro Pro template and a hazard index ranking was completed. Table 10., on the following page, lists this ranking by site number, location, indicator values and hazard index. Also shown is statistical information for the indicator values and hazard index.

During the process of field data collection and subsequent indicator computations, it was discovered that values for the two subjective indicators could vary widely between consecutive observations and among non-experienced observers. If Billings-should choose to duplicate these efforts in the future and continue this program, staff traffic personnel should be chosen who will continue to update the high hazard priority list on a long term basis and therefore, these indicators should remain as part of the hazard index ranking as long as consistency can be maintained.

TABLE 10. SITE RANKING BY HAZARD INDEX - SUMMARY OF INDICATOR VALUE

RANK NO.			# OF ACC. IND VAL	# OF ACC. PART H.I. Wgt. 16.4%	ACC. RATE IND VAL	ACC. RATE PART H.I. Wgt. 22.5%	SEVERITY IND VAL	SEVERITY PART H.I. Wgt. 19.1%	V/C RATIO IND VAL	V/C RATIO PART H.I. Wgt. 8.2%	SIGHT DIST IND VAL	SIGHT DIST PART H.I. Wgt. 7.4%	EXPECT. IND VAL	EXPECT. PART H.I. Wgt. 14.9%	INFO DEF. IND VAL	INFO DEF. PART H.I. Wgt. 11.5%	TOTAL HAZARD INDEX Wgt 100%
1	PARKHILL DRIVE	13TH STREET W	82	13.4	31	6.9	48	9.1	91	7.5	93	6.9	75	11.1	67	7.7	62.6
2	SECOND AVENUE N	N 31ST STREET	87	14.2	48	10.8	43	8.2	29	2.4	100	7.4	67	9.9	75	8.6	61.4
3	TWELFTH AVENUE N	N 30TH STREET	82	13.4	41	9.2	47	8.9	57	4.7	100	7.4	67	9.9	63	7.2	60.7
4	THIRD AVENUE N	N 31ST STREET	90	14.7	38	8.5	47	8.9	33	2.7	100	7.4	75	11.1	58	6.7	60.0
5	AVENUE B	19TH STREET W	76	12.4	61	13.7	49	9.3	19	1.6	23	1.7	75	11.1	83	9.5	59.3
6	TENTH AVENUE N	N 31ST STREET	72	11.7	93	20.8	39	7.4	17	1.4	32	2.4	58	8.6	58	6.7	59.0
7	HOWARD AVENUE	10TH STREET W	69	11.2	100	22.4	43	8.2	9	0.7	39	2.9	50	7.4	50	5.8	58.6
8	LEWIS AVENUE	8TH STREET W	76	12.4	21	4.7	48	9.1	100	8.2	51	3.8	83	12.3	67	7.7	58.2
9	YELLOWSTONE AVENUE	1ST STREET W	74	12.1	91	20.4	34	6.5	17	1.4	33	2.4	58	8.6	58	6.7	58.0
10	LEWIS AVENUE	6TH STREET W	79	12.9	33	7.4	47	8.9	50	4.1	100	7.4	71	10.5	58	6.7	57.9
11	WYOMING AVENUE	1ST STREET W	67	10.9	67	15.0	40	7.6	33	2.7	46	3.4	71	10.5	67	7.7	57.9
12	POLY DRIVE	VIRGINIA LANE	85	13.9	21	4.7	42	8.0	100	8.2	31	2.3	83	12.3	71	8.2	57.5
13	ELEVENTH AVENUE N	N 30TH STREET	72	11.7	29	6.5	46	8.7	42	3.4	100	7.4	79	11.7	63	7.2	56.8
14	FOURTH AVENUE S	S 39TH STREET	61	9.9	66	14.8	51	9.7	17	1.4	21	1.6	71	10.5	67	7.7	55.6
15	SECOND AVENUE N	N 28TH STREET	79	12.9	20	4.5	58	11.0	69	5.7	50	3.7	67	9.9	67	7.7	55.4
16	THIRD AVENUE N	N 25TH STREET	76	12.4	38	8.5	42	8.0	47	3.9	58	4.3	67	9.9	58	6.7	53.6
17	THIRD AVENUE N	N 23RD STREET	78	12.7	56	12.5	44	8.4	21	1.7	100	7.4	39	5.8	44	5.1	53.6
18	ALDERSON AVENUE	3RD STREET W	67	10.9	48	10.8	49	9.3	12	1.0	31	2.3	71	10.5	75	8.6	53.4
19	LEWIS AVENUE	1ST STREET W	67	10.9	23	5.2	51	9.7	59	4.8	100	7.4	58	8.6	58	6.7	53.3
20	SECOND AVENUE N	N 24TH STREET	67	10.9	36	8.1	45	8.6	28	2.3	100	7.4	50	7.4	61	7.0	51.6
21	HOWARD AVENUE	11TH STREET W	50	8.2	50	11.2	69	13.1	11	0.9	37	2.7	58	8.6	58	6.7	51.4
22	POLY DRIVE	13TH STREET W	87	14.2	27	6.0	41	7.8	63	5.2	35	2.6	54	8.0	58	6.7	50.4
23	LEWIS AVENUE	19TH STREET W	78	12.7	27	6.0	38	7.2	87	7.1	9	0.7	58	8.6	67	7.7	50.1
24	LEWIS AVENUE	10TH STREET W	50	8.2	11	2.5	44	8.4	32	2.6	100	7.4	75	11.1	71	8.2	48.3
25	SECOND AVE S	S 39TH STREET	61	9.9	61	13.7	46	8.7	13	1.1	13	1.0	50	7.4	50	5.8	47.5
	AVERAGE VALUES =		73		45		46		42		60		65		63		56
	STANDARD DEVIATIONS =		10		24		7		28		34		11		9		4

EXPLANATION OF IMPROVEMENTS

The recommended improvements presented within this report are short term improvements and reflect the minimum amount of upgrading or modifications necessary to increase driver expectancy and also update the sites to current standards. Long term improvements are only considered viable when severe conditions at the site prevent short term improvements from completely satisfying the control measures necessary to significantly reduce future problems. Since any long term improvements would be dependant upon significant changes in future traffic operations and most of the sites of this nature are covered by the transportation plan, no specific plans were advanced and no costs or project ranking was completed for long term improvements. However, general recommendations of a long term nature are made within the site specific section when applicable.

Many of the recommended improvements have sufficient latitude so that alternative measures could be suggested during design. The selection of recommended improvements was based on subjective engineering judgement. Basis of the recommendations incorporate an understanding of driver psychology, visual input requirements, accident statistics and comparative studies. Some of the recommended improvements are not directly related to accident prevention, but are required to meet current standards and provide consistent control measures. Specific reasons for recommendations are presented in the site specific section of this report.

Prior to subjecting the proposed improvements to review based on the status quo, it should be remembered that these study sites are not characteristic of all Billings intersections. They are documented as the highest accident locations in the City with exception of Federal Aid designated streets. As such, they require improvement measures not typical of other area intersections. If recommended improvements call for 36" stop signs and centerline striping, it should not be considered as justification for installing larger stop signs at all other intersections in the city or striping all centerlines. In most cases, 30" stop signs are completely adequate while in some cases, either because of sight restrictions; visual distractions on the horizon; lighting conditions or other various reasons, stop signs are simply not perceived by the driver. Recommendations for oversize stop signs in this study are

made when a visual obstruction is not apparent but there is strong evidence that the stop sign is not being perceived.

Since all of the study sites are recognized accident cluster locations, there is good statistical probability that the majority of accidents are not by chance. Therefore, street and traffic control conditions are likely deficient for expected traffic operations. Some of the deficiencies are entirely obvious once the facts have been examined. Others defy a clear cut answer with regard to cause and effect relationships. In all cases, improvements are geared toward improving the street system by relating to the driver's cognitive abilities. The first means of accomplishing this is to enhance visual perception by insuring a clear line of sight to all important information sources, ie. approaching vehicles and traffic control devices. The second factor related to driving functions is directed at sub-conscious perception, which is the major factor in driver expectancy. As an example, if a street section appears to be a thru street given visual clues such as wide pavement surfaces, minor side street traffic and an uninterrupted view to the horizon, even over-sized stop signs may be ignored. In this case, disruption of the pattern is required. It may take the form of a stop bar, cross walk or centerline striping at a stop controlled intersection. These are all methods of giving visual clues to the driver which subconsciously indicates that the approaching intersection requires actions different than did the previous intersections. Many of the recommended improvements within this study relate to the later means of providing information to the driver.

Recommendations for plastic pavement markings are replete throughout the study. Painted marks may be substituted to substantially reduce the City's cost. However, more intense maintenance will be needed if this alternative is chosen. If the marks are worn most of the time, they will not functioned as planned.

The improvement sketches, in some cases should not be considered design plans. Some of the more complex drawings are preliminary and are intended to present improvement concepts only in enough detail to provide the measure of control necessary and to provide cost estimates. In some cases, detailed survey data; design analysis; design plans and specifications; and construction layout will be necessary to effectively achieve the improvements.

BENEFIT/COST RATIOS

COSTS

Preliminary cost estimates are developed by applying unit costs to required quantities based either on current prices as tabulated from average bid prices of similar projects or, where applicable, on prices established by Montana Department of Transportation's Project Planning Section. The costs should in no way be considered a quote or final estimate of actual work.

The following are traffic control devices and allowable costs that are eligible for funding by the Montana Department of Transportation through their Off-System Safety Program:

A. Signs:

1. 1 square foot to 6 square feet - $ 100.00
2. 6.1 square feet to 10 square feet - $ 140.00
3. 10.1 square feet to 20 square feet - $ 170.00
4. supplementary sign on same post - $ 50.00

B. Delineators:

1. Design ""A" metal posts - $ 9.25
2. Design "A" flexible posts-6' - $ 20.00
3. Design "A" flexible posts-27" - $ 6.00

C. Guardrail:

1. New "W" Beam rail (per foot) - $ 8.00
2. "W" Beam end treatment (each) - $ 1,000.00
3. New concrete rail (per foot) - $ 16.00
4. New concrete end tapers (per foot) - $ 16.00

The Department of Justice and the Montana Department of Transportation are currently evaluating safety improvement costs within urban environments. Since the

above noted items do not adequately correlate with the nature of improvements within highly urbanized areas, other items such as pavement markings may be added to the funding eligibility list within the future.

Even though Billings street and traffic crews are capable of performing a good deal of work, costs related to physical changes in the roadway section are based on contract prices in order to correlate with costs requiring contract bid letting. The costs do not include administrative, engineering or field layout for the recommended improvements at sites which would require final design plans. Engineering design will generally be required to produce contract plans and specifications. These costs should be evaluated prior to planning improvement projects requiring bids.

BENEFITS

Estimated benefits are made by applying accident reduction forecasts based on the type of improvement recommended. The forecasts are based on the subjective evaluation by an experienced traffic engineer. This evaluation is aided by knowledge of accident experience at similar locations with the improvements existing. Also statistical studies relating certain improvements to accident reduction are used as a guide ie, Roy Jorgenson and Associates, *"Evaluation of Criteria for Safety Improvements on the Highway" (Washington, D.C.: U.S. Bureau of Public Roads, Office of Highway Safety, 1966. p. 316).*

The forecasted reduction is expressed as a percentage of each type of accident. This percentage is multiplied by the percentage of all accidents represented by each type. The total percent reduction of all accidents at each site is the sum of all accidents reduction percentages for each type.

The method used to compute benefits in this study follows the Montana Department of Transportation's procedures. Those procedures were programmed for Quattro Pro Computer Software which provides a tabular summary of all variables in the computation.

If applied consistently, the economic benefit computation will provide a realistic estimate of average economic savings to society. The benefit amount should not be interpreted as a dollar value that Billings will receive as a result of dollar outlay. It is a figure used to quantify the economic benefit to society that would occur if a certain number of accidents did not occur.

B/C RATIO

The B/C provides a numerical reference to the relative value of the recommended improvements. It is the desire of any improvement project to have a benefit-cost (B/C) ratio in excess of 1.0. If the B/C is less than 1.0 the project would have questionable justification. In this study, none of the sites had a B/C less than one.

Table 11 is a computer generated summary of the B/C ranking for the twenty five study sites. From this table it can be seen that the total capital cost of improvements would be approximately $ 132,000 or about $5,300 per site. The total projected benefit would be approximately $ 278,000, annually. The mean B/C ratio value was computed is approximastely 16, which translates into a 1600% return on investment.

The B/C indicator values encompass the full range of values from 0 to 100. The average value for all sites 60. An explanation of the B/C indicator value is given in the priority index section of this report.

TABLE 11. SITE RANKING BY BENEFIT/COST RATIOS

RNK #	SITE LOCATION		PROJ LIFE	CAPITOL COST IMPROVE	EQUIV ANNUAL COST	ANNUAL MAINT. COST CH.	TOTAL ANNUAL COST	Q	Afl	Apd	PFI	Ppd	ANNUAL BENEFIT	B/C RATIO	IND VAL
				COSTS				BENEFITS							
1	AVENUE B	19TH STREET W	5	$360	$95	$36	$131	$18,150	1.20	3.60	70%	59%	$19,904	151.98	100
2	ALDERSON AVENUE	3RD STREET W	5	$360	$95	$36	$131	$18,150	0.90	2.40	70%	64%	$14,811	113.09	100
3	HOWARD AVENUE	11TH STREET W	5	$360	$95	$36	$131	$18,150	1.50	0.90	50%	30%	$14,450	110.33	100
4	FOURTH AVENUE S	S 39TH STREET	5	$360	$95	$36	$131	$18,150	0.90	1.60	60%	50%	$11,845	90.44	98
5	SECOND AVE S	S 39TH STREET	5	$360	$95	$36	$131	$18,150	0.60	1.60	50%	33%	$6,772	51.71	86
6	HOWARD AVENUE	10TH STREET W	5	$410	$108	$41	$149	$18,150	0.60	2.70	45%	38%	$7,099	47.59	84
7	LEWIS AVENUE	1ST STREET W	5	$520	$137	$52	$189	$18,150	1.20	1.60	35%	23%	$8,629	45.81	83
8	YELLOWSTONE AVENUE	1ST STREET W	5	$360	$95	$36	$131	$18,150	0.00	3.90	0%	54%	$4,301	32.84	78
9	SECOND AVENUE N	N 24TH STREET	5	$880	$232	$88	$320	$18,150	0.60	2.70	60%	44%	$9,097	28.42	73
10	ELEVENTH AVENUE N	N 30TH STREET	5	$1,040	$274	$104	$378	$18,150	0.90	2.70	50%	34%	$10,214	27.00	72
11	LEWIS AVENUE	8TH STREET W	5	$2,000	$528	$200	$728	$18,150	1.20	4.20	50%	46%	$15,064	20.70	66
12	TENTH AVENUE N	N 31ST STREET	5	$560	$148	$56	$204	$18,150	0.30	3.30	30%	25%	$3,353	16.46	61
13	THIRD AVENUE N	N 31ST STREET	10	$9,470	$1,541	$400	$1,941	$18,150	1.60	6.31	70%	57%	$30,683	15.81	60
14	THIRD AVENUE N	N 23RD STREET	5	$1,890	$499	$189	$688	$18,150	0.90	3.60	47%	33%	$10,265	14.93	59
15	SECOND AVENUE N	N 31ST STREET	10	$8,200	$1,335	$400	$1,735	$18,150	1.20	5.41	65%	81%	$21,181	12.21	54
16	SECOND AVENUE N	N 28TH STREET	7	$3,840	$789	$380	$1,169	$18,150	2.70	3.30	20%	18%	$11,085	9.48	49
17	POLY DRIVE	VIRGINIA LANE	5	$1,990	$525	$199	$724	$18,150	0.90	5.11	27%	21%	$6,890	9.24	48
18	LEWIS AVENUE	10TH STREET W	5	$680	$179	$68	$247	$18,150	0.30	1.20	30%	23%	$2,231	9.02	48
19	WYOMING AVENUE	1ST STREET W	5	$1,520	$401	$152	$553	$18,150	0.30	2.70	5%	53%	$3,200	5.79	38
20	THIRD AVENUE N	N 25TH STREET	10	$7,706	$1,254	$220	$1,474	$18,150	0.60	3.60	40%	52%	$8,270	5.81	37
21	TWELFTH AVENUE N	N 30TH STREET	10	$20,990	$3,416	$700	$4,116	$18,150	1.50	3.90	62%	53%	$21,455	5.21	36
22	PARKHILL DRIVE	13TH STREET W	10	$23,140	$3,766	$800	$4,566	$18,150	1.50	4.50	53%	59%	$20,154	4.41	32
23	LEWIS AVENUE	8TH STREET W	7	$8,040	$1,651	$300	$1,951	$18,150	1.20	3.00	17%	12%	$4,516	2.31	18
24	LEWIS AVENUE	19TH STREET W	5	$3,760	$992	$378	$1,368	$18,150	0.30	4.20	20%	20%	$2,827	2.07	16
25	POLY DRIVE	13TH STREET W	10	$33,280	$5,416	$120	$5,536	$18,150	0.90	6.01	30%	37%	$9,537	1.72	12
	TOTALS :			$132,076	$23,761	$5,061	$28,822						$277,633		
	AVERAGES :		6.36	$5,283	$950	$202	$1,153				42%	40%	$11,105	33.36	60

PRIORITY INDEX

The ranking of site improvement priorities cannot be directly dependent on the hazard ranking of the study sites. The value of the improvements must enter into the priority listing in the form of the benefit/cost ratio (B/C). The method of developing a composite Hazard Index - B/C listing must be dependent on the relative index scale used in the hazard index computation. Therefor, a correlation of scale between the B/C ratio and hazard indicator value was developed on the following assumptions:

1. The contributing conditions creating hazards at each site and the resulting hazard ranking is relatively independent of the cost of correcting these conditions.
2. Benefits to be derived from correcting hazardous situations at each site is indirectly proportional to the degree of hazards encountered.
3. The benefit/cost ratio, by virtue of benefit computation, is indirectly proportional to the number of accidents indicator and severity indicator, both of which are curvilinear functions.
4. The benefit/cost ratios can be rated on a scale of 0 to 100 based on a curvilinear function.
5. The B/C ratio of 1.0 is equivalent to an indicator value of 0 and the upper limit (indicator value = 100) must be chosen to encompass the majority of sites.

In this case, a B/C of 100.0 and above assumes the indicator value of 100. Based on these assumptions a graphic plot of the B/C ratio versus B/C indicator value has been established and it is shown in Figure 10. Since it has been graphed on semi-log paper the line appears linear.

Since the relative weighting of benefit/costs and hazard indexes is a controversial subject which would require research beyond the scope of this report, it is felt that

the priority index should be based on 33% weighting for the benefit-cost ratio and 67% weight on the hazard index. Therefore, to establish a priority index the following formula has been devised:

$$\textit{Priority Index} = (\textit{Hazard Index}) \times (0.67) + (\textit{Benefit/Cost Indicator}) \times (0.33)$$

Table 12. is the computer generated summary of priority ranking based on the composite hazard index - benefit/cost index values.

TABLE 12. SITE RANKING BY PRIORITY INDEX - SUMMARY

PRIORITY NUMBER	AVENUE	STREET	HAZARD INDEX	WEIGHTED VALUE	BEN/COST INDEX	WEIGHTED VALUE	PRIORITY INDEX
1	AVENUE B	19TH STREET W	59.30	39.73	100	33.00	72.73
2	FOURTH AVENUE S	S 39TH STREET	55.60	37.25	98	32.34	69.59
3	ALDERSON AVENUE	3RD STREET W	53.40	35.78	100	33.00	68.78
4	HOWARD AVENUE	11TH STREET W	51.40	34.44	100	33.00	67.44
5	HOWARD AVENUE	10TH STREET W	58.60	39.26	84	27.72	66.98
6	YELLOWSTONE AVENUE	1ST STREET W	58.00	38.86	76	25.08	63.94
7	LEWIS AVENUE	1ST STREET W	53.30	35.71	83	27.39	63.10
8	ELEVENTH AVENUE N	N 30TH STREET	56.80	38.06	72	23.76	61.82
9	LEWIS AVENUE	6TH STREET W	57.90	38.79	66	21.78	60.57
10	SECOND AVE S	S 39TH STREET	47.50	31.83	86	28.38	60.21
11	THIRD AVENUE N	N 31ST STREET	60.00	40.20	60	19.80	60.00
12	TENTH AVENUE N	N 31ST STREET	59.00	39.53	61	20.13	59.66
13	SECOND AVENUE N	N 31ST STREET	61.40	41.14	54	17.82	58.96
14	SECOND AVENUE N	N 24TH STREET	51.80	34.71	73	24.09	58.80
15	THIRD AVENUE N	N 23RD STREET	53.60	35.91	59	19.47	55.38
16	POLY DRIVE	VIRGINIA LANE	57.50	38.53	48	15.84	54.37
17	SECOND AVENUE N	N 28TH STREET	55.40	37.12	49	16.17	53.29
18	TWELFTH AVENUE N	N 30TH STREET	60.70	40.67	36	11.88	52.55
19	PARKHILL DRIVE	13TH STREET W	62.60	41.94	32	10.56	52.50
20	WYOMING AVENUE	1ST STREET W	57.90	38.79	38	12.54	51.33
21	LEWIS AVENUE	10TH STREET W	48.30	32.36	48	15.84	48.20
22	THIRD AVENUE N	N 25TH STREET	53.60	35.91	37	12.21	48.12
23	LEWIS AVENUE	8TH STREET W	58.20	38.99	18	5.94	44.93
24	LEWIS AVENUE	19TH STREET W	50.10	33.57	16	5.28	38.85
25	POLY DRIVE	13TH STREET W	50.40	33.77	12	3.96	37.73
	AVERAGE VALUES :		55.69	37.31	60.24	19.88	57.19
	STANDARD DEVIATIONS :		4.08	2.74	26.42	8.72	8.96

PRIORITY INDEX = (HAZARD INDEX x 0.67) + (BENEFIT/COST INDEX x 0.33)

IMPLEMENTATION

Within Table 13, the priority lists have been arranged in a manner in which budget considerations can readily be applied in the decision to proceed with improvements. The priority ranking was the major consideration in selecting which sites will be receiving funds first. Since limited funds are available, it is usually necessary to skip over a few higher priority projects to improve a greater number of sites as soon as possible. The listing assumes that eligible project costs will be funded by MDoT Off-system Safety funds. The MDoT project funding limit is less than $10,000 per project period, or else formal bid letting procedures would be required by MDoT. This dollar figure is used as the criteria to define construction groupings. In this case, all of the MDoT funded project could be covered within a years period. If a decision by MDoT is made which will include other items, their funding contribution could increase substantially which would require separating the list into smaller numbers of projects or construction groupings. The estimated costs not covered by MDoT funds are considered City funding requirements. If the Billings Street and Traffic Division performs this work, the actual costs would probably be much less.

There is no timetable given for these improvements. It may be conceivable that MDoT could fund more than one of the site groups in a single year, depending on available funding. The City will want to request funding from MDoT by submitting this report to Dave Johnson, P.E., Preconstruction Engineer.

TABLE 13. PROJECT IMPLEMENTATION SCHEDULE

PRIORITY NO.	AVENUE	STREET	COST ESTIMATE	MDoT ELIGIBLE FUNDS	CITY FUNDS
1	AVENUE B	19TH STREET W	$360	$200	$160
2	FOURTH AVENUE S	S. 39TH STREET	$360	$200	$160
3	ALDERSON AVENUE	3RD STREET W	$360	$200	$160
4	HOWARD AVENUE	11TH STREET W	$360	$200	$160
5	HOWARD AVENUE	10TH STREET W	$410	$200	$210
6	YELLOWSTONE AVENUE	1ST STREET W	$360	$200	$160
7	LEWIS AVENUE	1ST STREET W	$520	$280	$240
8	ELEVENTH AVENUE N	N. 30TH STREET	$1,040	$400	$640
9	LEWIS AVENUE	6TH STREET W	$2,000	$860	$1,140
10	SECOND AVENUE S	S. 39TH STREET	$360	$200	$160
11	THIRD AVENUE N	N. 31ST STREET	$9,470	$280	$9,190
12	TENTH AVENUE N	N. 31ST STREET	$560	$400	$160
13	SECOND AVENUE N	N. 31ST STREET	$8,200	$480	$7,720
14	SECOND AVENUE N	N. 24TH STREET	$880	$480	$400
15	THIRD AVENUE N	N. 23RD STREET	$1,890	$480	$1,410
16	POLY DRIVE	VIRGINIA LANE	$1,990	$100	$1,890
17	SECOND AVENUE N	N. 28TH STREET	$3,840	$400	$3,440
18	TWELFTH AVENUE N	N 30TH STREET	$20,990	$350	$20,640
19	PARKHILL DRIVE	13TH STREET W	$23,140	$1,660	$21,480
20	WYOMING AVENUE	1ST STREET W	$1,520	$400	$1,120
21	LEWIS AVENUE	10TH STREET W	$680	$340	$340
22	THIRD AVENUE N	N. 25TH STREET	$7,706	$420	$7,286
23	LEWIS AVENUE	8TH STREET W	$8,040	$500	$7,540
24	LEWIS AVENUE	19TH STREET W	$3,760	$560	$3,200
25	POLY DRIVE	13TH STREET W	$33,280	$280	$33,000
	TOTAL CONSTRUCTION COSTS =		$132,076	$10,070	$122,006

STREET CORRIDORS

Two separate street segments were identified in the preliminary accident screening process as having continuous accidents cluster sites along their length. The City of Billings had requested that these corridors be examined as part of this study. Since this situation was noted early in the study process, accident reports along the corridor were separated and used in the analysis. Conditions and operations along these corridors were observed and general recommendations are made with regard to improving the safety and efficiency of these corridors. The following narratives present those recommendations.

LEWIS AVENUE

Lewis Avenue is a two way east-west collector street that begins at Division Street on the west fringe of the CBD and continues west to Parkview Drive, in West Billings, a distance of 3.5 miles. Since Lewis Avenue parallels Grand Avenue, a major arterial which has operated at capacity for approximately 20 years, it carries a significant amount of cross town, arterial type traffic. For many years residents along Lewis Avenue have downplayed the significance of Lewis Avenue as a thru street, even to the point of protesting increased speed limits (currently 25 mph). Past improvements to Broadwater Avenue (south of Lewis) has significantly retarded potential traffic traffic growth on Lewis Avenue. If not for those improvements, Lewis Avenue would currently carry traffic volumes in excess of its capacity. At present traffic volumes along the subject corridor are approximately 7,000 ADT. The capacity of Lewis Avenue, as it exists, is approximately 8,000 to 9,000 ADT at level-of-service "C".

The corridor in question is that section of Lewis Avenue between First Street West and Eight Street West. Within this section of road three of its intersections, 1st Street West, 6th Street West and 8th Street West are among the twenty five study intersection sites. Improvements recommended at the first two intersections focus on improving sight distance onto Lewis from a stopped position on the side

street and creating an awareness of the stop condition from side street approaches. Improvements at the 8th Street West intersection are of a different character than the remainder of Lewis. Specific information on that intersection can be found in the site specific section of this report.

The following accident statistics apply to this corridor:

Total Number of Accidents in 3.33 Year Period =	66
Section Length =	1.0 Miles
Accident Rate =	7.8 Acc/mvm
Number of Injury Accidents=	18
Number of Injuries =	27
Number of Mid-block Accidents =	8 (12%)
Number of Nighttime Accidents =	15 (22%)
Number of Angle Accidents =	40
Number of Rearend Accidents =	10
Number of Sideswipe Accidents =	4
Number of Parked Car Accidents =	4
Number of Left Turn Accidents =	1
Number of Single Vehicle Accidents =	3
Number of Other Type Accidents =	4

Accident problems along the corridor consist mostly of angle accidents. A significant percentage of accidents occur during nighttime hours since only 7.8% of total accidents occurred during hours of darkness at all of the study sites. Existing lighting consists of pole top luminaires mounted at approximately 12 feet. The street surface appears to be well lit but glare is a distinct problem. All of the side streets have the same lighting which make the area fairly uniform. This uniformity does not help distinguish the existence of Lewis Avenue as the thru street.

Lewis Avenue is only 35' wide from back of curb to back of curb and carries two lanes of traffic. Parking is prohibited on the north side of the street which allows for 2 - 12' driving lanes. Some of the side streets east of 5th Street West are 46

feet wide. This fact also contributes to a general lack of visual clues that Lewis is a thru street. Considering that Lewis carries traffic volumes that are 10 to 15 times higher than the average side street and it is as narrow or narrower than all of the side streets, it is not surprising that at least 80% of the angle accidents happen because of drivers missing the stop signs. The remaining 20% of the accidents occur because of visual obstructions related to parked cars and trees in the boulevard.

As a short term solution it is recommended that visual obstructions be cleared at all intersections, especially on the side street approaches where trees or vehicles may be blocking total view of the stop signs. Parking restrictions at intersections should be implemented, either by curb painting or signing. Intersection sight distance calculations should be based on the observed 85% speed and not the speed limit. Centerline markings and stop bars should be painted on the approaches to Lewis Avenue at 2nd, 3rd, 4th and 7th Streets West to add visual clues regarding the stop condition.

Long term solutions cannot be ignored forever. At some point in the future, traffic volumes will increase to a level where the short term improvements have no significant effect. At that time Lewis Avenue will have to be widened to provided a minimum three lane section and the intersection geometry modified to eliminate sight restrictions. The speed limit may also have to be increased. It is apparent that designing facilities for an artificially low speed limit can be dangerous to the majority of the driving public.

NORTH 30TH STREET

North 30th Street is a two-lane, two-way minor arterial street which serves north-south traffic flow through the medical corridor of Billings. It is a minor access route for trips between the CBD and residential areas north and west of the CBD. Because of its orientation and connection to the downtown one-way grid system it has a biased flow in the southbound direction and its peak hour is normally in the morning. North 30th extends from Montana Avenue on the south to Poly Drive on

the north. The section of this street concerned with the corridor study is between 6th Avenue North and 12th Avenue North. Two of its intersections, 12th and 11th Avenues North are among the studies twenty five intersection sites. Another intersection, 10th Avenue North, was among top ranking sites in the study's preliminary site screening process, but because of recent changes to that intersection, it was not included among the twenty five.

The following accident statistics apply to this corridor:

Total Number of Accidents in 3.33 Year Period =	54
Section Length =	0.61 Miles
Accident Rate =	11.7 Acc/mvm
Number of Injury Accidents=	11
Number of Injuries =	11
Number of Mid-block Accidents =	4 (7%)
Number of Nighttime Accidents =	5 (9%)
Number of Angle Accidents =	31
Number of Rearend Accidents =	11
Number of Sideswipe Accidents =	3
Number of Parked Car Accidents =	1
Number of Left Turn Accidents =	7
Number of Single Vehicle Accidents =	1
Number of Other Type Accidents =	0

As can be seen the accident rate is significantly higher than average and also higher than the Lewis Avenue corridor. Nighttime accidents are not significant. The predominant accident type is the angle accident with rearend and left turn accidents being other significant types. The majority of angle accidents occurring on North 30th Street are reported to involve vehicles which had stopped prior to entering the intersection from the side street. Therefore visibility of the stop control is not the major problem, but intersection sight distance from the side streets at the stop sign is a problem.

North 30th is 51' in width (BC-BC) and has parking on both sides. Estimated 85% speeds on this corridor would be near 35 mph. At the intersections of 11th and 12th Avenues North, a dynamic vehicle model was made which calculates critical intersection entering and crossing gaps for side street traffic. From those gaps and geometry of the intersections, clear line of sight lines were drawn. It was determined that parking on N. 30th had to be significantly restricted to provide the required line of sight. In one case it was recommended to narrow the street width by constructing curb bulbs at the intersection, thereby allowing a vehicle to stop further into the street section and improving the line of sight. This was considered necessary because of the existence of stationary sight restrictions as well as parking interference. In the other case, a significant amount of parking was eliminated as a recommendation. Because of significant left turn maneuvers at 12th Avenue N., marked left turn bays were also recommended.

Similar conditions exist at all of the remaining intersections on N. 30th Street. Because of that fact, the basic recommendation for the corridor would be to improve intersection sight distance for the side street stop condition. This could be accomplished by either eliminating significant amounts of parking on both sides of N. 30th Street or by constructing curb bulbs at all corners of the intersections. Since parking is at a premium in this area, the later recommendation would be more suitable and has additional benefits. The curb bulbs effectively narrow the street at the intersection where shorter pedestrian crossing distances are required. The narrower intersections allow less latitude for errant vehicle movements and allows for easier marking of lane assignments. Future improvements should also include provisions for three traffic lanes or marked left turn bays at contiguous intersections. This would provide full utilization of the wide street with safer operating characteristics.

PROGRAM CONTINUATION

Since the basic format of the study has been outlined and an initial priority list established, continuance of this program or a similar program is strongly advised. The findings and recommendations of this study will soon become obsolete without continued updating at least on an annual basis. The following recommendations in the continuance of the program are offered to the City of Billings:

1. The City Engineer's office should continue to receive accident reports from the Police Department.
2. One person should be assessed with the responsibility of the program to insure that all data is being supplied and processed.
3. An agreement with the City Police Department should be made which would modify computer reporting to identify cluster sites or a separate program should be used to store basic data from the police reports as they are received by the Traffic Engineering Section.
4. Criteria should be developed for the inclusion of additional sites to be analyzed, such as number of accidents, accident rate and severity.
5. Coordinate existing traffic counting programs to include areas that may not currently be covered. With broad enough coverage, estimates of volumes on all street segments can be made for screening purposes.
6. Analyze new sites according to all or selected procedures of this study and include them in the priority list when warranted.

All of the data processing and storage can be handled by most computer spreadsheet software programs. A copy of the data disk has been provided to the City of Billings. If translation problems occur between these data files and the City's spread sheet program, they can be translated to a ASCII file.

REPORT

FIGURES

HAZARD

INDICATOR

VALUES

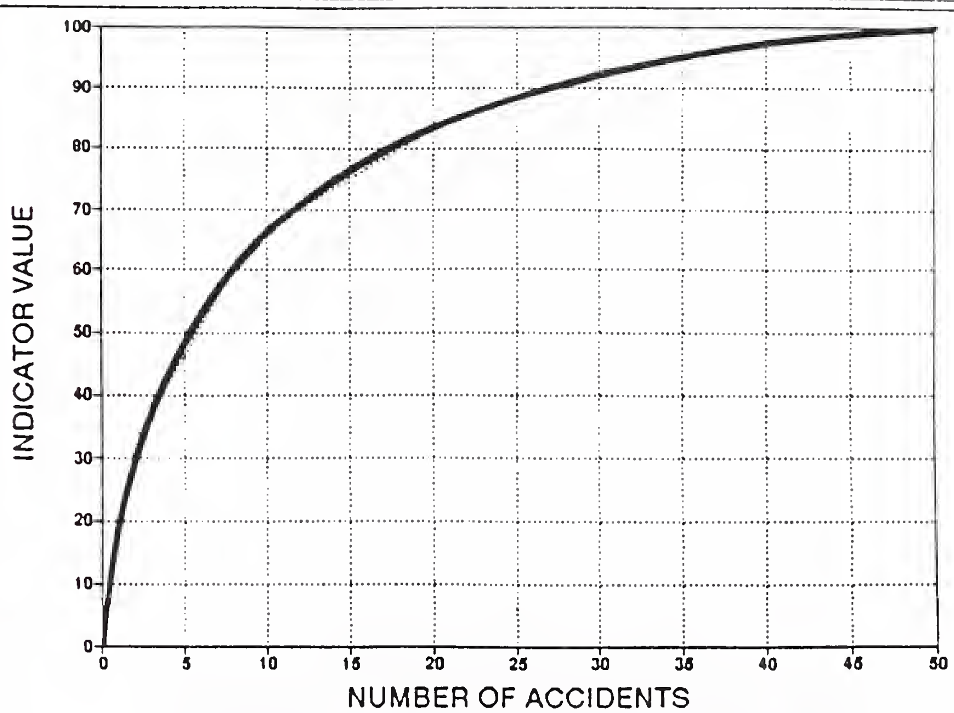


FIGURE 6 NUMBER OF ACCIDENTS INDICATOR

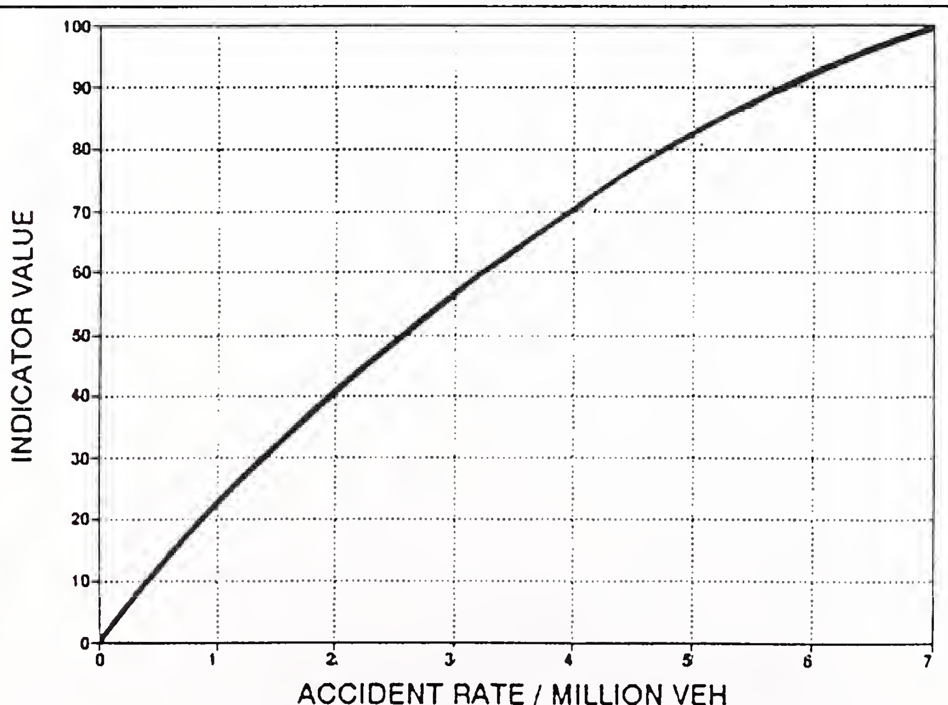


FIGURE 7 ACCIDENT RATE INDICATOR

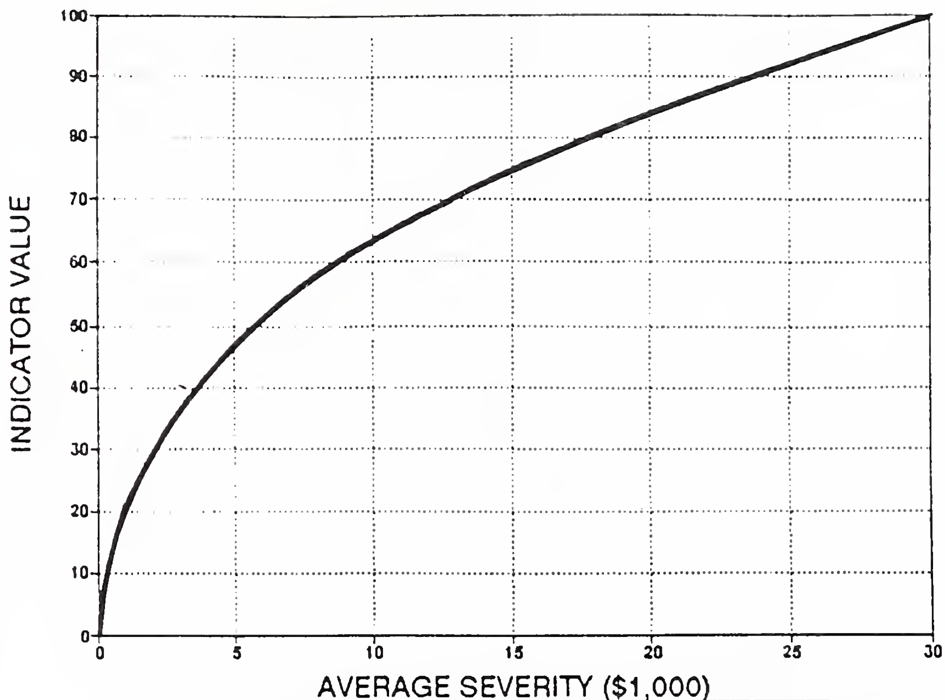


FIGURE 8 ACCIDENT SEVERITY INDICATOR

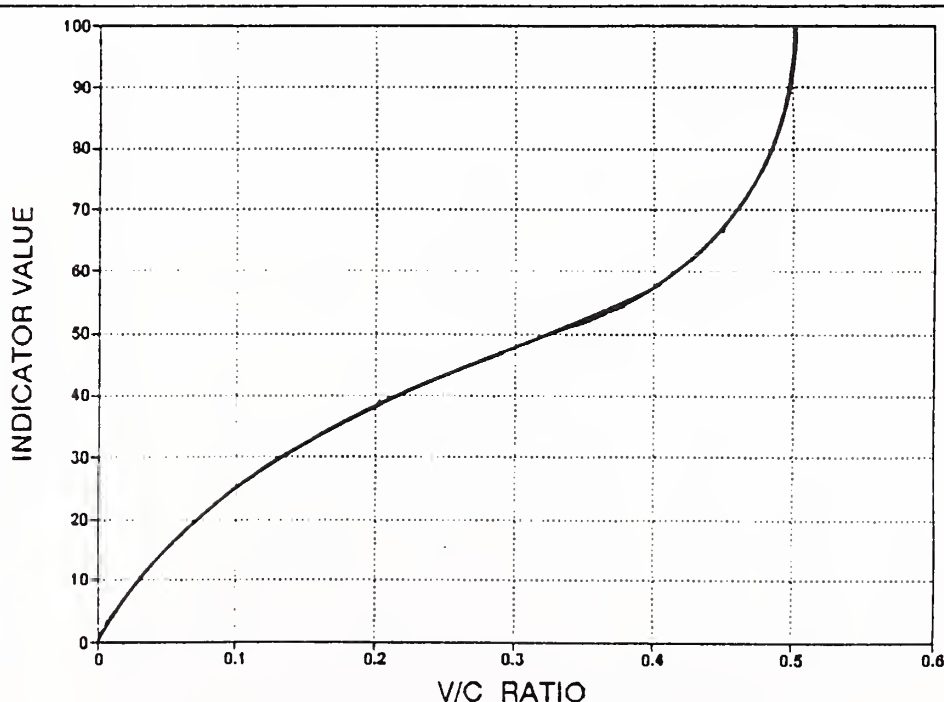


FIGURE 9 V/C RATIO INDICATOR

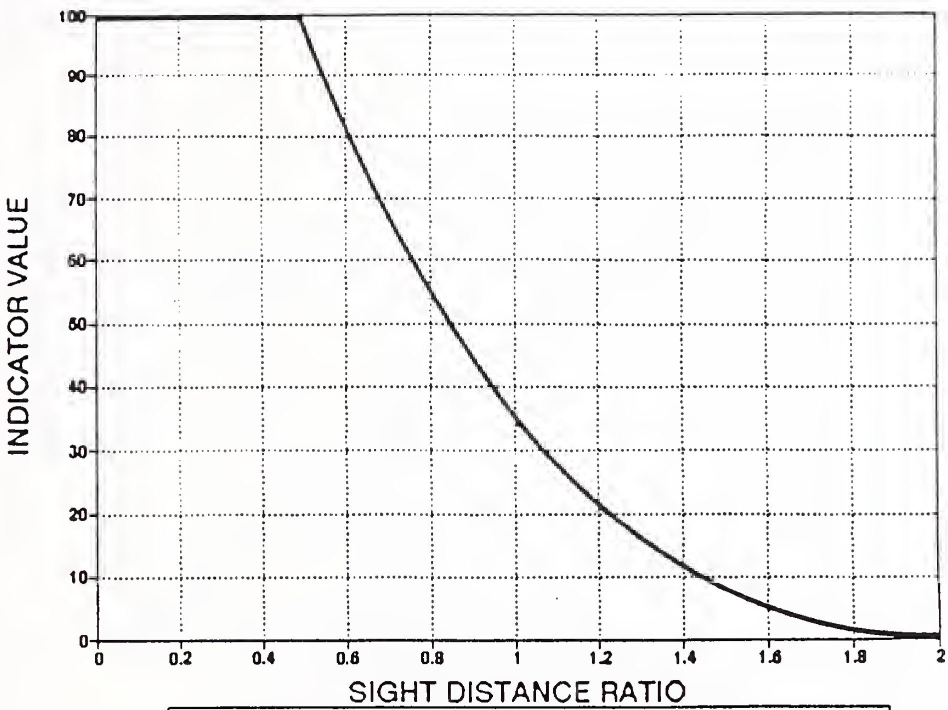


FIGURE 10 SIGHT DISTANCE RATIO INDICATOR

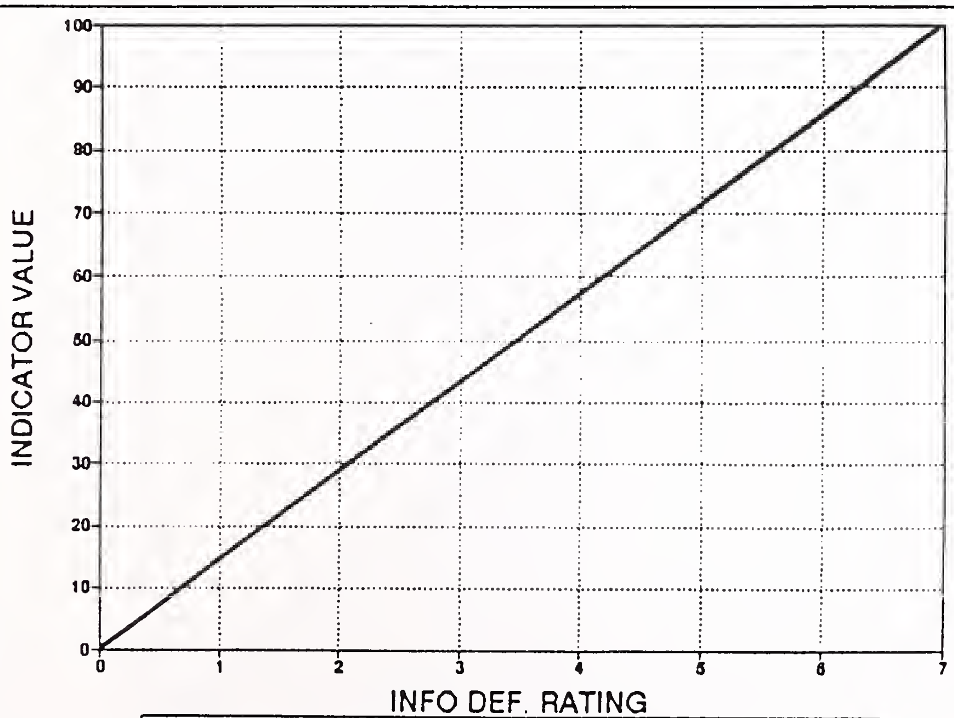


FIGURE 11 INFORMATION DEFICENCY INDICATOR

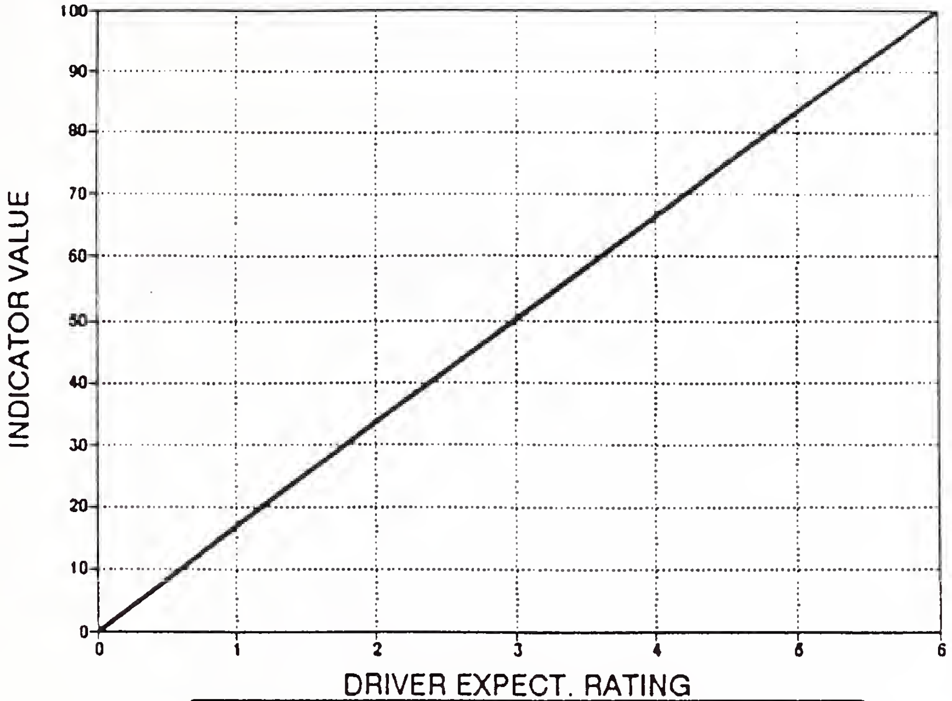


FIGURE 12 DRIVER EXPECTANCY INDICATOR

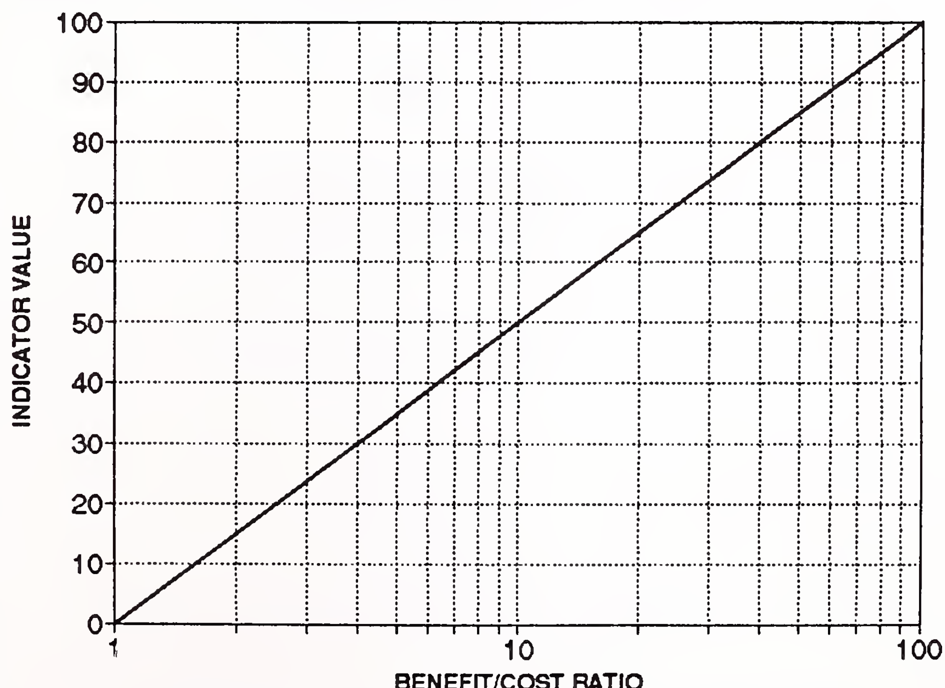


FIGURE 13. BENEFIT/COST RATIO INDICATOR

INDIVIDUAL SITES

SPECIFIC

DATA

&

ANALYSIS

SITE

NUMBER

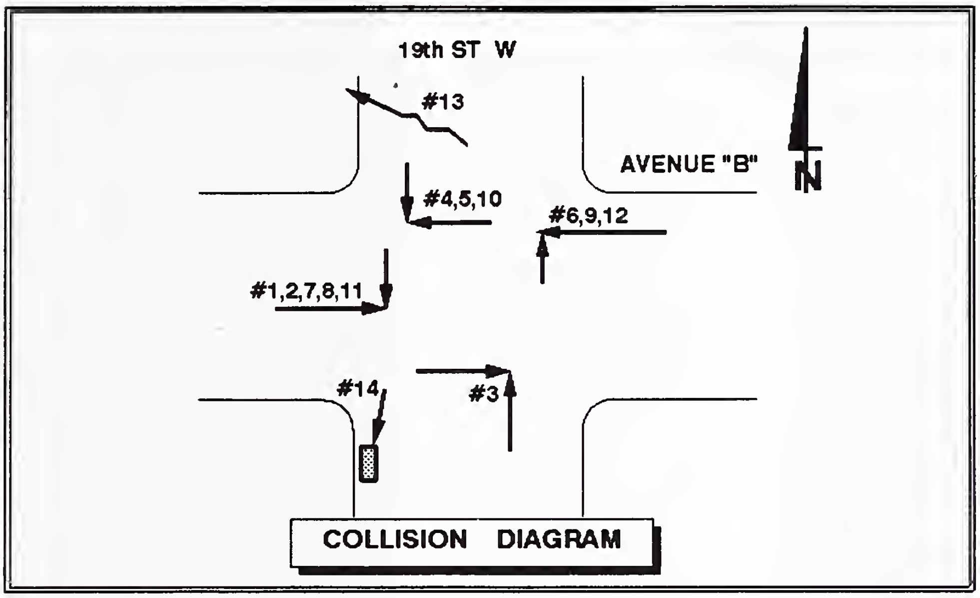
1

AVENUE B

and

19TH STREET WEST

ACCIDENT SUMMARY
AVENUE "B" & 19TH STREET W



ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	5	24	88	1610	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	10	12	88	755	INJURY	CLEAR	DRY	DAY
3	ANGLE	11	15	88	1432	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	2	4	89	1015	PROP DAM	CLEAR	ICY	DAY
5	ANGLE	12	4	89	1104	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	12	28	89	31	PROP DAM	CLEAR	ICY	NITE
7	ANGLE	1	3	90	1229	PROP DAM	CLEAR	ICY	DAY
8	ANGLE	7	28	90	1119	PROP DAM	CLEAR	DRY	DAY
9	ANGLE	10	28	90	338	PROP DAM	CLEAR	DRY	NITE
10	ANGLE	12	21	90	1930	PROP DAM	CLEAR	ICY	NITE
11	ANGLE	1	7	91	1725	PROP DAM	CLEAR	ICY	NITE
12	ANGLE	3	20	91	1609	INJURY	CLEAR	DRY	DAY
13	FIXED OBJ	12	16	90	330	PROP DAM	CLEAR	ICY	NITE
14	PARKED CAR	1	3	90	1243	PROP DAM	CLEAR	ICY	DAY

ACCIDENT KEY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
3	1988	NO. INJURY	2
3	1989	NO. FATAL	0
6	1990	NO. PDO	12
2	1991	PER INJ=	4
14	TOTAL	NIGHTIME	36%

TYPES	NUMBER	ROAD	
ANGLE	12	DRY	50%
REAR END	0	WET	0%
SIDESWIPE	0	SNOW	0%
LEFT TRN	0	ICE	50%
OTHER	2	OTHER	0%

19TH ST. W. LOOKING NORTH

19TH ST. W. LOOKING SOUTH

AVENUE "B" LOOKING EAST

AVENUE "B LOOKING WEST

TRAFFIC OPERATIONS

Avenue B is a local street which runs parallel to Grand Avenue in an east west direction. Nineteenth Street West is a collector street running north and south. North of Grand Avenue, at the intersection site, it is classified as a local street. Several years ago a traffic signal was installed at Grand Avenue and 19th Street West. Since that time traffic volumes on 19th north of Grand Avenue have increased steadily. Because of congestion on Grand Avenue, very little opportunity is afforded side street traffic to enter and 19th has provided the access opportunity. The signal not only concentrated traffic on 19th, but also attracts circulation traffic from Grand Avenue by serving as a left turn detour.

This intersection would appear, to the driver, similar to any other intersection of local streets, except the southbound driver is able to see the signal at 19th, which provides a subtle clue that he may be on a through street. A driver would also tend to time his approach with the intent of making a green light. Both of these, no matter how minor, would effect the driver's expectations as far as his reaction to unexpected side street traffic. Observations indicate that approximately 75% of 19th Street drivers do not even slow for the intersection while 50 % of Avenue B drivers slow or stop at the intersection. Even though there are no permanent sight restriction at this intersection, there is a significant angle accident problem.

IMPROVEMENTS

Twelve angle accidents at this intersection vehicles seem to support the observed operational problems encountered at this intersection. Because of extreme difference in approach leg traffic volumes; the presence of visual miscues; potential sight distance restrictions; and accident history, it is recommended that this intersection be controlled by stop signs on the Avenue B approaches. There are no apparent thru street patterns in this area or difficult grades which would preclude the use of this control feature. In addition to stop signs, it is advised that curbs should also be painted yellow, from the end radius points. Since traffic is increasing on 19th Street West, other Avenues north of Grand should be monitored to see if accident problems develop which may require 19th Street West to be designated a thru street.

AVENUE B & 19TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	2400
SOUTH APP	2900
EAST APP	700
WEST APP	1100

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$360
MDoT FUND	$200
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	70%
PDO	60%

BENEFIT/COST RATIO: 152

	INDEX VALUE	SITE RANK
# ACCIDENTS	76	11
ACCIDENT RATE	61	7
SEVERITY	49	6
VOL/CAPACITY	19	18
SIGHT DIST.	23	22
DRIVER EXPECT	75	6
INFO DEFICIENT	83	1
HAZARD INDEX	59.3	5
B/C RATIO	100	1

PRIORITY	72.73	1

SITE

NUMBER

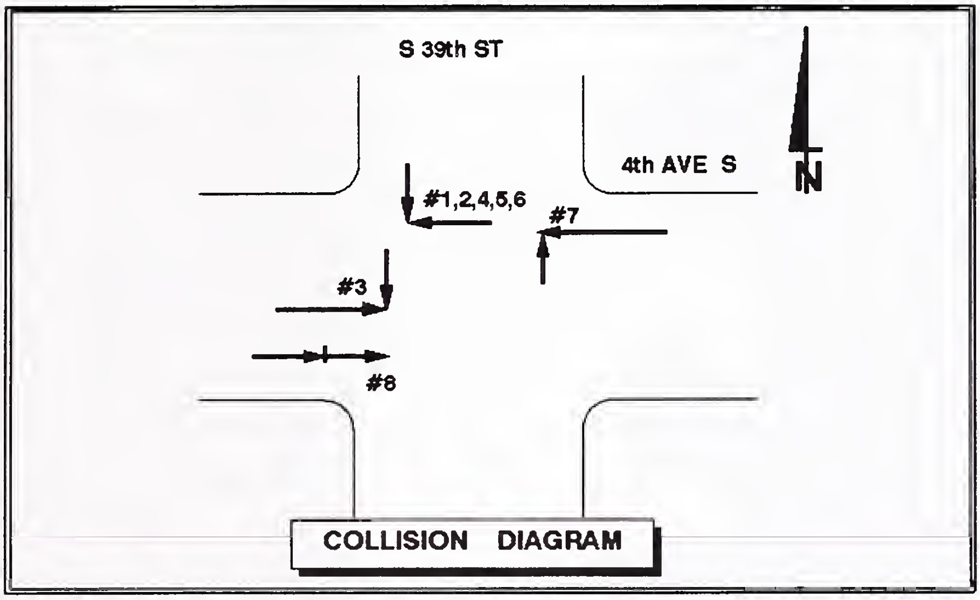
2

FOURTH AVENUE S.

and

S. 39TH STREET

ACCIDENT SUMMARY
FOURTH AVE S & S 39TH STREET



ACC NO.	ACCIDENT TYPE	ACCIDENT KEY MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	2	3	88	1621	PROP DAM	SNOW	ICY	DAY
2	ANGLE	12	1	88	1650	INJURY	CLEAR	DRY	DAY
3	ANGLE	1	12	89	1330	PROP DAM	CLEAR	ICY	DAY
4	ANGLE	5	13	90	2223	PROP DAM	CLEAR	DRY	NITE
5	ANGLE	11	5	90	1600	PROP DAM	CLEAR	WET	DAY
6	ANGLE	3	1	91	1658	PROP DAM	SNOW	SNOW	DAY
7	ANGLE	4	6	91	1332	INJURY	CLEAR	DRY	DAY
8	REAREND	5	29	88	821	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
3	1988	NO. INJURY	2
1	1989	NO. FATAL	0
2	1990	NO. PDO	6
2	1991	PER INJ=	3
8	TOTAL	NIGHTIME	13%

TYPES	NUMBER	ROAD	
ANGLE	7	DRY	50%
REAR END	1	WET	13%
SIDESWIPE	0	SNOW	13%
LEFT TRN	0	ICE	25%
OTHER	0	OTHER	0%

S. 39TH ST. LOOKING NORTH

S. 39TH ST. LOOKING SOUTH

FOURTH AVE. S. LOOKING EAST

FOURTH AVE. S. LOOKING WEST

TRAFFIC OPERATIONS

Fourth Avenue S. and S. 39th Street are two local streets in a residential neighborhood on the south end of Billings. S. 39th Street is also one of several north-south streets that serve as a connector between two arterial streets, State Avenue and 1st Avenue South. Because these arterial streets intersect in a wye approximately 1/4 mile west of this intersection, several of the local cross streets serve cross traffic between them. Thus, traffic volumes are higher in a north-south direction. At this intersection, this traffic pattern is translated into heavy right and left turn movements between the north and west legs, because of the skewed grid system (see area map). This intersection is also within 300 feet of an intersection with State Avenue and a railroad crossing. Vehicles entering the intersection from the State Avenue side tend to assume right of way in their favor because they have just exited an arterial. Southbound right turning traffic also enters the intersection without proper attention to potential conflicts to cross traffic. There were seven angle accidents at this intersection during the reporting period. All but two of those accidents involved southbound and eastbound vehicles where there are no permanent sight restrictions.

IMPROVEMENTS

It is apparent that driver habit is controlling operations at this intersection. Most of the accidents involved local residents who undoubtedly use this intersection quite frequently. Accidents occur when the assumed direction of travel by approaching vehicles does not meet the drivers' expectancy. Other drivers not as familiar with this intersection are more attentive to potential conflicts and are sometimes confused by lack of control. In addition, 50% of the accidents occurred on wet or icy roads. Lower speeds on any of the approaches may have resulted in fewer accidents in these instances.

Because of relatively low traffic volumes and the directional flow of traffic at this intersection, it is recommended that yield signs be installed on the Fourth Avenue N. approach legs of this intersection. This control is expected to provide more reaction time when road conditions are less than ideal and provide a clear indication of vehicular right of way. A proposed future closure of S. 39th Street will require a reevaluation when State Avenue is rebuilt.

FOURTH AVENUE S. 7 S. 39TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1200
SOUTH APP	300
EAST APP	750
WEST APP	1600

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	YES
STOP	
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$360
MDoT FUND	$200
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	60%
PDO	50%

BENEFIT/COST RATIO: 90

	INDEX VALUE	SITE RANK
# ACCIDENTS	61	22
ACCIDENT RATE	66	5
SEVERITY	51	3
VOL/CAPACITY	17	21
SIGHT DIST.	21	23
DRIVER EXPECT	71	9
INFO DEFICIENT	67	11
HAZARD INDEX	55.6	14
B/C RATIO	98	4

PRIORITY	69.59	2

SITE

NUMBER

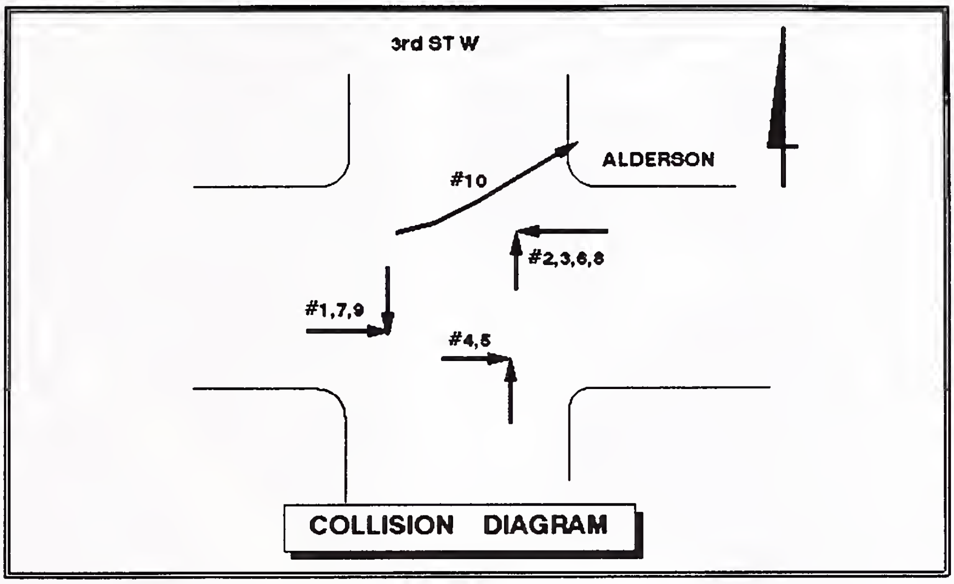
3

ALDERSON AVENUE

and

3RD STREET WEST

ACCIDENT SUMMARY
ALDERSON AVE & 3RD STREET W



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	5	16	88	1452	INJURY	CLEAR	DRY	DAY
2	ANGLE	10	28	88	1159	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	2	3	89	1335	PROP DAM	CLEAR	ICY	DAY
4	ANGLE	2	17	89	1136	PROP DAM	SNOW	ICY	DAY
5	ANGLE	3	23	90	1300	PROP DAM	SNOW	ICY	DAY
6	ANGLE	10	5	90	1625	PROP DAM	RAIN	WET	DAY
7	ANGLE	11	1	90	1505	INJURY	RAIN	WET	DAY
8	ANGLE	11	9	90	1144	PROP DAM	CLEAR	DRY	DAY
9	ANGLE	12	23	90	1444	PROP DAM	CLEAR	ICY	DAY
10	FIXED OBJ	4	27	90	841	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	2
2	1989	NO. FATAL	0
6	1990	NO. PDO	8
0	1991	PER INJ=	3
10	TOTAL	NIGHTIME	0%

TYPES	NUMBER	ROAD	
ANGLE	9	DRY	40%
REAREND	0	WET	20%
SIDESWIPE	0	SNOW	0%
LEFT TRN	0	ICE	40%
OTHER	1	OTHER	0%

3RD ST. W. LOOKING NORTH

3RD ST. W. LOOKING SOUTH

ALDERSON AVE. LOOKING EAST

ALDERSON AVE. LOOKING WEST

TRAFFIC OPERATIONS

Alderson Avenue is a local street which runs parallel and one block south of Grand Avenue, a major east-west arterial. Third Street West is a local street street running north and south. The study intersection is currently uncontrolled. A traffic signal has controlled the intersection of Third Street W at Grand Avenue for a number of years. A curb, gutter, sidewalk and resurfacing project was completed on 3rd in 1989. Six of the ten accidents occurred in 1990 after the street project was complete. All but one of the accidents at this intersection were angle accidents. One of the reasons for this is that the new street section is wider and has the appearance of a thru street. Another reason is that traffic approaching the Grand Avenue form the south drive toward the signal with the majority of the driver's attention focused on the signal and completely blocks out the existence of the Alderson intersection. This situation was observed during the study. Approximately 80% of southbound drivers traverse the intersection without the slightest of head turn and without adjusting speed. In the northbound direction, the percentage increases up to 90 percent. Approximately 40% of Alderson Avenue traffic actually stops and 30% slows substantially at this intersection.

IMPROVEMENTS

From accident history and operational observations it is entirely clear that this intersection requires vehicular right of way control. Because of high traffic volumes on 3rd Street W. and current operational trends, it is recommended that stop signs be installed on Alderson Avenue. In order to avoid any potential intersection sight distance problems that may occur because of parked cars or trucks, it is also recommended that curbs be painted yellow in the intersection areas. This action is expected to reduce the current accident problems substantially.

ALDERSON AVENUE & 3RD STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	3200
SOUTH APP	2800
EAST APP	700
WEST APP	700

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$360
MDoT FUND	$200
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	70%
PDO	64%

BENEFIT/COST RATIO: 113

	INDEX VALUE	SITE RANK
# ACCIDENTS	67	18
ACCIDENT RATE	48	10
SEVERITY	49	5
VOL/CAPACITY	12	23
SIGHT DIST.	31	20
DRIVER EXPECT	71	10
INFO DEFICIENT	75	3
HAZARD INDEX	53.4	18
B/C RATIO	100	2

PRIORITY	68.7	3

SITE

NUMBER

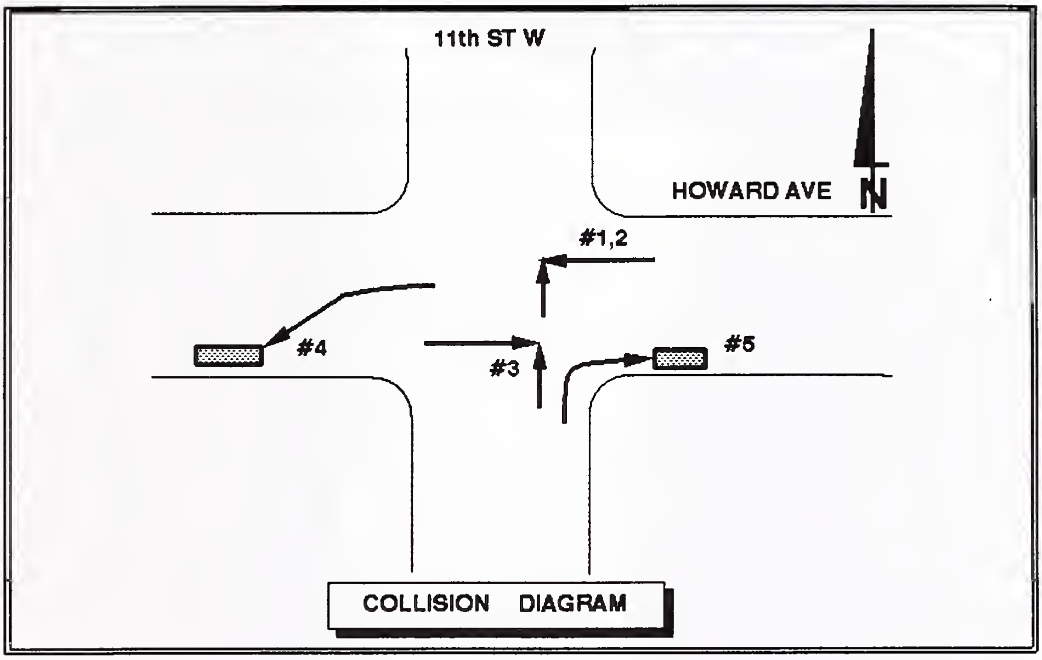
4

HOWARD AVENUE

and

11TH STREET WEST

ACCIDENT SUMMARY
HOWARD AVE & 11TH STREET W



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	7	13	88	1935	INJURY	CLEAR	DRY	DAY
2	ANGLE	10	21	88	1810	INJURY	CLEAR	DRY	DAY
3	ANGLE	12	19	90	1610	PROP DAM	CLEAR	ICY	DAY
4	PARKED CAR	7	31	89	57	INJURY	CLEAR	DRY	NITE
5	PARKED CAR	11	2	90	1327	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	3
1	1989	NO. FATAL	0
2	1990	NO. PDO	2
0	1991	PER INJ=	5
5	TOTAL	NIGHTIME	20%

TYPES	NUMBER	ROAD	
ANGLE	3	DRY	80%
REAR END	0	WET	0%
SIDESWIPE	0	SNOW	0%
LEFT TRN	0	ICE	20%
OTHER	2	OTHER	0%

11TH ST. W. LOOKING NORTH

11TH ST. W. LOOKING SOUTH

HOWARD AVE. LOOKING EAST

HOWARD AVE. LOOKING WEST

TRAFFIC OPERATIONS

Howard Avenue and 11th Street West are two local streets in a residential neighborhood on the west end of Billings. Traffic volumes on the streets are fairly low, but 11th Street West volumes are significantly higher than those on Howard Avenue. The road surfaces of each street are in very poor condition. This situation causes drivers to divert part of their attention to navigating through the rough spots. A large evergreen tree in the northeast corner provides a slight sight restriction. Observations indicate that drivers do not follow any particular pattern in their approach to the intersection. No one direction of approached causes greater caution on the part of the drivers.

Three angle accidents which have occurred at this intersection ocurred in the northeast and southwest corners. This indicates that the sight restriction in the northeast corner is not particularly more severe than what may be associated with the southwest corner. The two other accidents involved vehicles hitting parked cars in intersection corners which indictes there may also be a parking problem that also restricts sight distance.

IMPROVEMENTS

Because of the difference in approach leg traffic volumes; sight restrictions; and accident history, it is recommended that this intersection be controlled on the lower volume Howard Avenue approaches. Since mobile sight restrictions may be prevented by painting curbs yellow, the recommended controls are yield signs. Since this intersection is currently uncontrolled and traffic volumes are low, yield signs should slow traffic enough on two approaches to provide adequate sight distance for proper avoidance maneuvers. If after a period of time, the accident problem has not been significantly reduced stop control should be implemented.

HOWARD AVENUE & 11TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	950
SOUTH APP	1150
EAST APP	700
WEST APP	650

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	YES
STOP	
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$360
MDoT FUND	$200
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	50%
PDO	30%

BENEFIT/COST RATIO: 110

	INDEX VALUE	SITE RANK
# ACCIDENTS	50	24
ACCIDENT RATE	50	9
SEVERITY	69	1
VOL/CAPACITY	11	24
SIGHT DIST.	37	16
DRIVER EXPECT	58	19
INFO DEFICIENT	58	22
HAZARD INDEX	51.4	21
B/C RATIO	100	3

PRIORITY	67.44	4

SITE

NUMBER

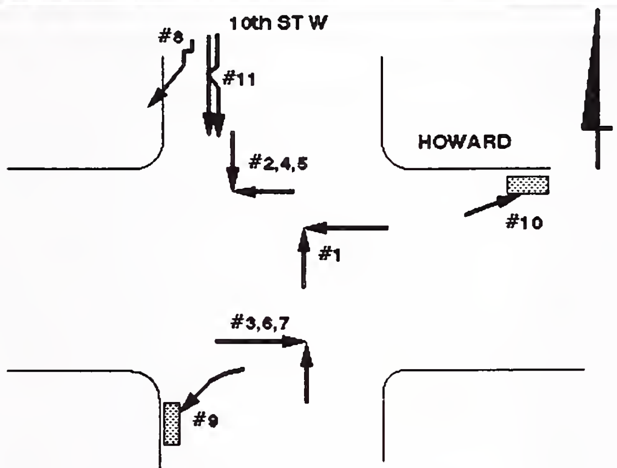
5

HOWARD AVENUE

and

10TH STREET WEST

ACCIDENT SUMMARY
HOWARD AVE & 10TH ST W



COLLISION DIAGRAM

ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	1	31	88	1142	PROP DAM	CLEAR	SNOW	DAY
2	ANGLE	8	2	88	1248	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	3	1	89	1304	PROP DAM	SNOW	SNOW	DAY
4	ANGLE	6	11	90	1654	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	8	21	90	753	INJURY	CLEAR	DRY	DAY
6	ANGLE	1	23	91	1604	PROP DAM	CLEAR	ICY	DAY
7	ANGLE	1	26	91	1150	PROP DAM	CLEAR	ICY	DAY
8	FIXED OBJ	12	3	88	300	PROP DAM	CLEAR	DRY	NITE
9	PARKED CAR	5	22	88	37	PROP DAM	CLEAR	DRY	NITE
10	PARKED CAR	8	18	89	211	INJURY	CLEAR	DRY	NITE
11	SIDESWIPE	6	18	90	1850	PROP DAM	RAIN	WET	DAY

ACCIDENT STATISTICS

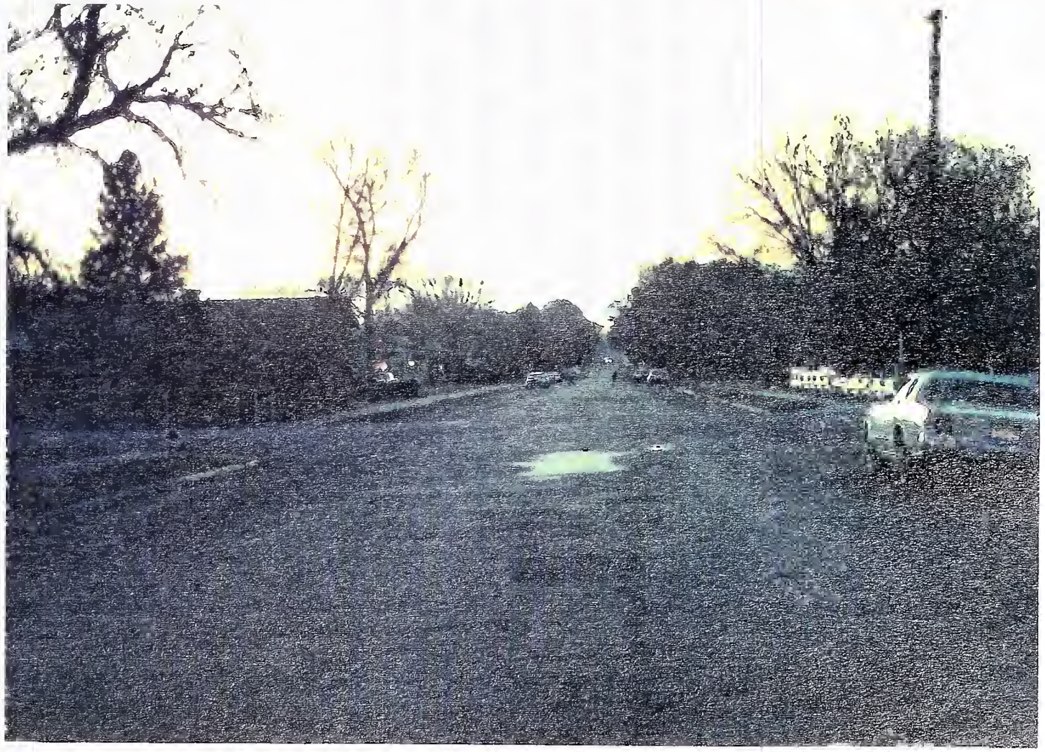
NO. ACC.	YEAR		
4	1988	NO. INJURY	2
2	1989	NO. FATAL	0
3	1990	NO. PDO	9
2	1991	PER INJ=	2
11	TOTAL	NIGHTIME	27%

TYPES	NUMBER	ROAD	
ANGLE	7	DRY	55%
REAREND	0	WET	9%
SIDESWIPE	1	SNOW	18%
LEFT TRN	0	ICE	18%
OTHER	3	OTHER	0%

10TH ST. W. LOOKING NORTH

10TH ST. W. LOOKING SOUTH

HOWARD AVE. LOOKING EAST



HOWARD AVE. LOOKING WEST

TRAFFIC OPERATIONS

Howard Avenue and 10th Street West are two local streets in a residential neighborhood on the west end of Billings. Traffic volumes on the streets are fairly low, but 10th Street West volumes are approximately double those on Howard Avenue. The road surfaces of each street are in very poor condition. This situation causes drivers to divert part of their attention to navigating through the rough spots. A large evergreen tree, lilac bush and chain link fence in the southwest corner restricts sight distance. Observations indicate that drivers do not follow any particular pattern in their approach to the intersection. No one direction of approached causes greater caution on the part of the drivers.

Seven angle accidents which have occurred at this intersection represent most combinations of directional travel. This indicates that the imposing sight restrictions in the southwest corner are not particularly more severe than what may be associated with the northeast corner.

IMPROVEMENTS

Because of the difference in approach leg traffic volumes; sight restrictions; and accident history, it is recommended that this intersection be controlled on the lower volumes Howard Avenue approaches. Since a portion of the sight restriction can be reduced by trimming lilac bushes in the southwest corner and mobile sight restrictions can be prevented by painting curbs yellow, the recommended controls are yield signs. Since this intersection is currently uncontrolled and traffic volumes are low, yield signs should slow traffic enough on two approaches to provide adequate sight distance for proper avoidance maneuvers. If after a period of time, the accident problem has not been significantly reduced stop control should be implemented.

HOWARD AVENUE & 10TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1000
SOUTH APP	900
EAST APP	350
WEST APP	450

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	YES
STOP	
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$410
MDoT FUND	$200
CITY FUND	$210

% ACCIDENT REDUCTION:

INJ/FTL	45%
PDO	38%

BENEFIT/COST RATIO: 48

	INDEX VALUE	SITE RANK
# ACCIDENTS	69	17
ACCIDENT RATE	100	1
SEVERITY	43	17
VOL/CAPACITY	9	25
SIGHT DIST.	39	15
DRIVER EXPECT	50	22
INFO DEFICIENT	50	23
HAZARD INDEX	58.6	7
B/C RATIO	84	6

PRIORITY	66.98	5

SITE

NUMBER

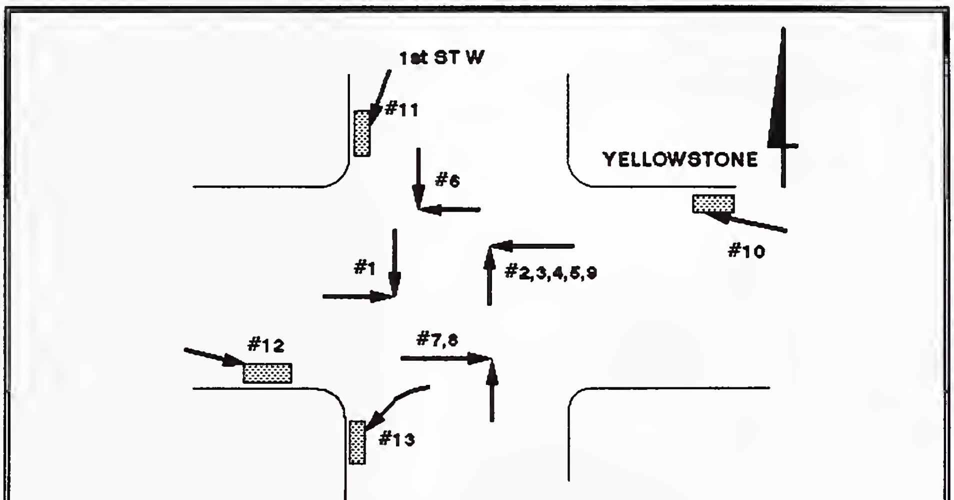
6

YELLOWSTONE AVENUE

and

1ST STREET WEST

ACCIDENT SUMMARY
YELLOWSTONE AVE & 1ST ST W



COLLISION DIAGRAM

ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	2	9	88	745	PROP DAM	SNOW	WET	DAY
2	ANGLE	6	18	88	1155	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	10	25	88	1007	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	1	3	89	1208	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	2	5	89	1415	PROP DAM	SNOW	SNOW	DAY
6	ANGLE	5	20	89	1137	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	8	6	90	1930	PROP DAM	CLEAR	DRY	DAY
8	ANGLE	9	13	90	1310	PROP DAM	CLEAR	DRY	DAY
9	ANGLE	12	4	90	1024	PROP DAM	CLEAR	DRY	DAY
10	PARKED	2	9	88	735	PROP DAM	CLEAR	ICY	NITE
11	PARKED CAR	9	27	88	2032	PROP DAM	CLEAR	DRY	DAY
12	PARKED CAR	3	3	90	1721	PROP DAM	CLEAR	DRY	DAY
13	PARKED CAR	11	27	90	1438	PROP DAM	CLEAR	ICY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
5	1988	NO. INJURY	0
3	1989	NO. FATAL	0
5	1990	NO. PDO	13
0	1991	PER INJ=	0
13	TOTAL	NIGHTIME	8%

TYPES	NUMBER	ROAD	
ANGLE	9	DRY	69%
REAREND	0	WET	8%
SIDESWIPE	0	SNOW	8%
LEFT TRN	0	ICE	15%
OTHER	4	OTHER	0%

1ST ST. W. LOOKING NORTH

1ST ST. W. LOOKING SOUTH

YELLOWSTONE AVE. LOOKING EAST

YELLOWSTONE AVE. LOOKING WEST

TRAFFIC OPERATIONS

Yellowstone Avenue and 1st Street West are local streets just west of the CBD. First Street West is a north-south street paralleling Division Street which is an arterial on the CBD fringe. First Street West carries more traffic than other local streets in the area because it is the first street west of Division which has continuity between Grand Avenue and Broadwater Avenue, two east-west arterials. It is a wide, smooth street with no traffic controls other than those at Grand, Lewis and Broadwater. Yellowstone Avenue is narrower than 1st, but it is also in very good conditions. The majority of westbound traffic on Yellowstone Avenue has an origin from Division Street and it is estimated that a significant portion of that traffic is using Yellowstone as a short cut to Lewis Avenue. Observations indicate that drivers on 1st assume that they are on a thru street and westbound drivers on Yellowstone are typically in a hurry. Nine angle accidents, eight of which involved westbound vehicles, seem to support operational observations.

IMPROVEMENTS

An imbalance in approach traffic volumes at this intersection indicates that vehicular right-of-way control may be suited to this intersection. Since traffic volumes are not extremely high and no permanent sight restrictions exist it is recommended that yield signs be placed on Yellowstone Avenue. They will tend to slow approaching traffic on Yellowstone and provide more positive right of way control. To ensure that temporary sight restrictions do not negate benefits of the yield situation, parking restrictions at corners should be marked by painting curbs yellow. All intersections on 1st Street West should be monitored in the future to determine if it should be designated as a thru street.

YELLOWSTONE AVENUE & 1ST STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1300
SOUTH APP	1400
EAST APP	600
WEST APP	450

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	YES
STOP	
SIGNAL	
MARKING	YES
REGULATORY	
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$360
MDoT FUND	$200
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	0%
PDO	54%

BENEFIT/COST RATIO: 33

	INDEX VALUE	SITE RANK
# ACCIDENTS	74	14
ACCIDENT RATE	91	3
SEVERITY	34	25
VOL/CAPACITY	17	19
SIGHT DIST.	33	18
DRIVER EXPECT	58	18
INFO DEFICIENT	58	19
HAZARD INDEX	58	9
B/C RATIO	76	8

PRIORITY	61.96	6

SITE

NUMBER

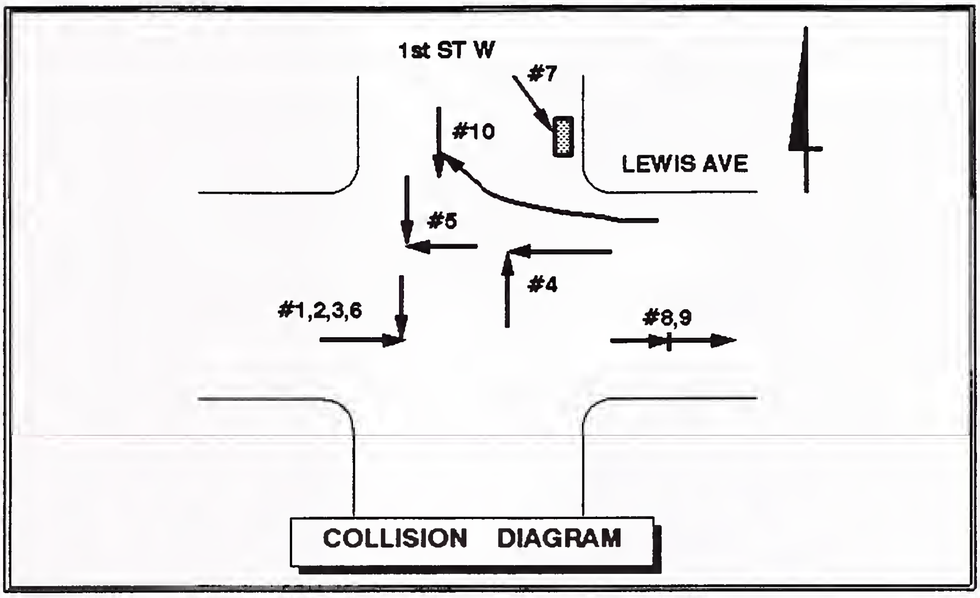
7

LEWIS AVENUE

and

1ST STREET WEST

ACCIDENT SUMMARY
LEWIS AVE & 1ST STREET W



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	12	3	88	1447	INJURY	CLEAR	DRY	DAY
2	ANGLE	2	22	89	935	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	10	11	89	1432	INJURY	CLEAR	DRY	DAY
4	ANGLE	11	5	90	728	PROP DAM	RAIN	WET	DAY
5	ANGLE	11	12	90	747	PROP DAM	CLEAR	ICY	DAY
6	ANGLE	12	24	90	1813	INJURY	SNOW	SNOW	NITE
7	PARKED CAR	3	9	88	2132	PROP DAM	CLEAR	DRY	NITE
8	REAREND	6	17	88	1346	PROP DAM	CLEAR	DRY	DAY
9	REAREND	8	1	90	1757	INJURY	CLEAR	DRY	DAY
10	SIDESWIPE	1	19	88	1339	PROP DAM	CLEAR	ICY	NITE

ACCIDENT STATISTICS

NO. ACC.	YEAR		
4	1988	NO. INJURY	4
2	1989	NO. FATAL	0
4	1990	NO. PDO	6
0	1991	PER INJ=	4
10	TOTAL	NIGHTIME	30%

TYPES	NUMBER	ROAD	
ANGLE	6	DRY	60%
REAR END	2	WET	10%
SIDESWIPE	1	SNOW	10%
PEDESTRIAN	0	ICE	20%
OTHER	1	OTHER	0%

1ST ST. W. LOOKING NORTH

1ST ST. W. LOOKING SOUTH

LEWIS AVE. LOOKING EAST

LEWIS AVE. LOOKING WEST

TRAFFIC OPERATIONS

Lewis Avenue is an east-west collector street while 1st Street West is a local north-south street. Their intersection is located one block west of Division Street which is on the western fringe of the CBD. This intersection is one of three Lewis Avenue intersection sites included in the Lewis Avenue corridor portion of this study. The primary operational problem noted at this intersection involves perception of street characteristics on 1st Street West. First Street West is wider than Lewis throughout its length. All other cross streets along 1st Street are also wider than Lewis and the intersection areas are plainly visible. The Lewis intersection does not provide adequate visual information of its existence nor of the importance of Lewis Avenue to drivers on 1st Street. To make matters worse, the stop signs are partially obstructed from view by power poles in the boulevard area and sometimes by parked pickup trucks.

There were six angle accidents at this intersection during the reporting period. All but two of these accidents involved drivers who failed to stop for the stop signs. Operational problems with driver expectancy correlate well with the history of this intersection.

IMPROVEMENTS

From accident history and operational observations it is felt that pavement markings could be used to enhance the required stop condition on 1st Street. Stop bars and centerline stripes on the two approaches would accomplish this when the pavement is clear. In addition, 36" stop signs mounted closer to the curb line will help emphasize the stop condition. Appropriately marked yellow curb will reduce the chance of vehicle obstructing the line of sight.

LEWIS AVENUE & 1ST STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1350
SOUTH APP	1700
EAST APP	7300
WEST APP	7800

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$520
MDoT FUND	$280
CITY FUND	$240

% ACCIDENT REDUCTION:

INJ/FTL	35%
PDO	23%

BENEFIT/COST RATIO: 46

	INDEX VALUE	SITE RANK
# ACCIDENTS	67	19
ACCIDENT RATE	23	21
SEVERITY	51	4
VOL/CAPACITY	59	7
SIGHT DIST.	100	6
DRIVER EXPECT	58	16
INFO DEFICIENT	58	16
HAZARD INDEX	53.3	19
B/C RATIO	83	7

PRIORITY	63.94	7

SITE

NUMBER

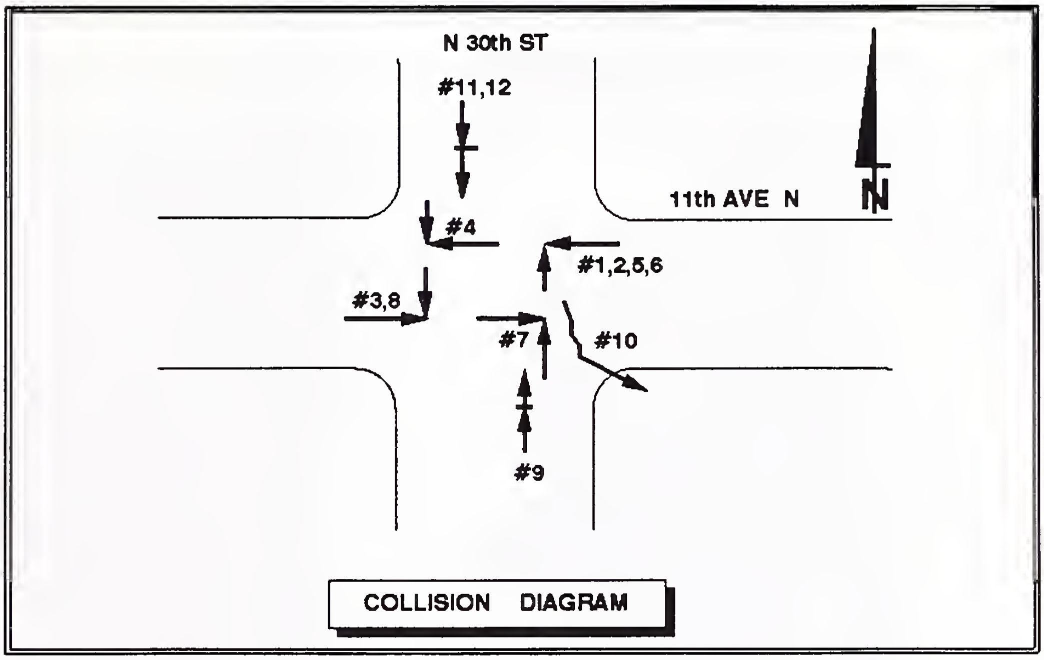
8

ELEVENTH AVENUE N.

and

N. 30TH STREET

ACCIDENT SUMMARY
ELEVENTH AVE N & N 30TH STREET



ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
		ACCIDENT KEY							
1	ANGLE	6	20	88	1511	INJURY	CLEAR	DRY	DAY
2	ANGLE	10	7	88	1511	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	12	27	89	942	INJURY	CLEAR	ICY	DAY
4	ANGLE	1	15	90	837	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	4	10	90	1800	PROP DAM	SNOW	DRY	DAY
6	ANGLE	1	28	91	830	PROP DAM	SNOW	ICY	DAY
7	ANGLE	3	4	91	1543	INJURY	CLEAR	DRY	DAY
8	ANGLE	3	15	91	815	PROP DAM	CLEAR	DRY	DAY
9	BACKING	6	26	89	752	PROP DAM	CLEAR	DRY	DAY
10	FIXED OBJ	2	22	90	2133	PROP DAM	CLEAR	DRY	NITE
11	REAREND	1	7	89	1517	PROP DAM	CLEAR	DRY	DAY
12	REAREND	2	19	91	1626	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	3
3	1989	NO. FATAL	0
3	1990	NO. PDO	9
4	1991	PER INJ=	3
12	TOTAL	NIGHTIME	8%

TYPES	NUMBER	ROAD	
ANGLE	8	DRY	83%
REAR END	2	WET	0%
SIDESWIPE	0	SNOW	0%
BIKE/PED	0	ICE	17%
OTHER	2	OTHER	0%

N. 30TH ST. LOOKING NORTH

N. 30TH ST. LOOKING SOUTH

ELEVENTH AVE. N. LOOKING EAST

ELEVENTH AVE. N. LOOKING WEST

TRAFFIC OPERATIONS

North 30th Street is a minor arterial north-south street within the original townsite grid orientation. Its intersection with 11th Avenue North is one of two intersections on N.30th Street analyzed within this study. The N. 30th Street corridor is evaluated within the main body of this report. Eleventh Avenue N. is a local east-west street which has been classified as a collector within the medical corridor area. The intersection area is fairly wide open with no permanent sight obstructions. The most obvious problem observed was parked vehicles. At certain times of the day on-street parking fills both streets. The parked vehicles make it very difficult for vehicles on the side street to view traffic on N. 30th Street. The view of stop signs on the side street approaches are sometimes obscured by parked vehicles. Also, there are no other visual clues to the stop condition when approaching the intersection from the side street. Four of the eight angle accidents, the majority of which involved westbound and northbound vehicles, were attributed to vehicles who had stopped prior to entering the intersection. Observations indicate that a significant number of drivers inch their way into the intersection until a clear line of sight is gained.

IMPROVEMENTS

Higher speeds on N. 30th along with parked cars and a wide street combine to increase the required intersection sight distance. A single unit design vehicle acceleration model was developed to determine critical traffic gaps and required sight distances at this intersection. By applying these distances to the intersection layout plan, restricted parking zones were determined, as shown on the short term improvement sketch. These zones will require signing and yellow curb paint. Since extensive distances are involved in this case, the City may want to consider whether corner bulb islands as recommended for corridor improvements would be preferred at this location. Other improvements utilizes centerline, cross walk and stop bar markings to improve visual clues to intersection control. Painting an additional 10' of yellow curb on 11th Avenue north approaches will also reduce the possibilities of parked vehicles obstructing views of the stop signs.

ELEVENTH AVENUE N. & N. 30TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	6600
SOUTH APP	6800
EAST APP	1800
WEST APP	1700

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$1,040
MDoT FUND	$400
CITY FUND	$640

% ACCIDENT REDUCTION:

INJ/FTL	50%
PDO	34%

BENEFIT/COST RATIO: 27

	INDEX VALUE	SITE RANK
# ACCIDENTS	72	15
ACCIDENT RATE	29	18
SEVERITY	46	12
VOL/CAPACITY	42	11
SIGHT DIST.	100	3
DRIVER EXPECT	79	3
INFO DEFICIENT	63	13
HAZARD INDEX	56.8	13
B/C RATIO	72	10

PRIORITY	61.82	8

SITE

NUMBER

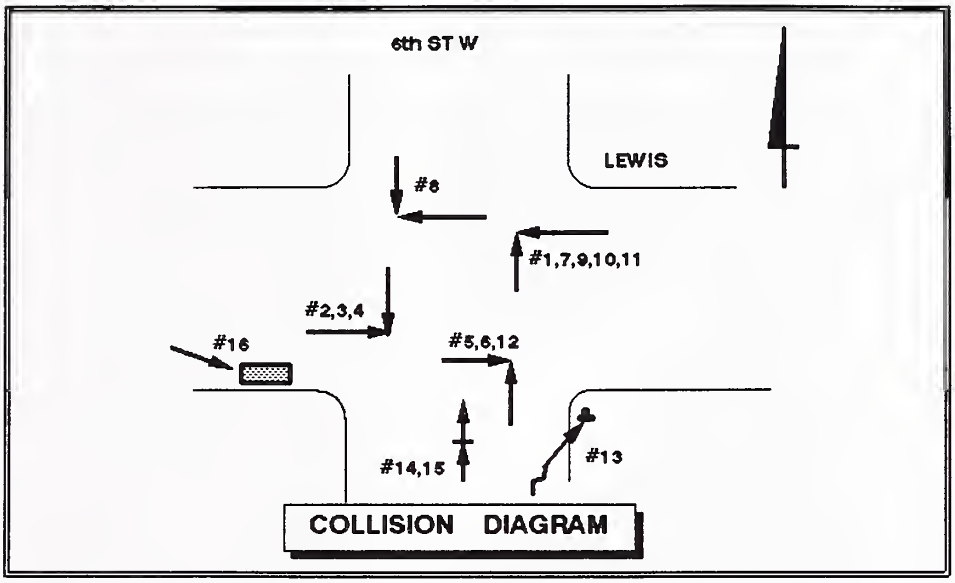
9

LEWIS AVENUE

and

6TH STREET WEST

ACCIDENT SUMMARY
LEWIS AVE & 6TH STREET W



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	3	1	88	1436	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	6	20	88	1459	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	1	3	89	1320	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	3	15	89	821	PROP DAM	CLEAR	ICY	DAY
5	ANGLE	5	21	89	946	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	6	27	89	1730	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	9	7	89	1242	PROP DAM	CLEAR	DRY	DAY
8	ANGLE	1	13	90	2205	PROP DAM	CLEAR	DRY	NITE
9	ANGLE	7	7	90	124	INJURY	CLEAR	DRY	NITE
10	ANGLE	10	15	90	1233	INJURY	CLEAR	DRY	DAY
11	ANGLE	12	14	90	1203	PROP DAM	CLEAR	SNOW	DAY
12	ANGLE	3	22	91	755	PROP DAM	CLEAR	DRY	DAY
13	FIXED OBJ	6	26	90	1803	PROP DAM	CLEAR	DRY	DAY
14	REAREND	3	6	90	1200	PROP DAM	CLEAR	DRY	DAY
15	REAREND	3	22	90	810	PROP DAM	SNOW	ICY	DAY
16	PARKED CAR	5	31	90	1613	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	2
5	1989	NO. FATAL	0
8	1990	NO. PDO	14
1	1991	PER INJ=	4
16	TOTAL	NIGHTIME	13%

TYPES	NUMBER	ROAD	
ANGLE	12	DRY	81%
REAREND	2	WET	0%
SIDESWIPE	0	SNOW	6%
LEFT TRN	0	ICE	13%
OTHER	2	OTHER	0%

6TH ST. W. LOOKING NORTH

6TH ST. W. LOOKING SOUTH

LEWIS AVE. LOOKING EAST

LEWIS AVE. LOOKING WEST

TRAFFIC OPERATIONS

Lewis Avenue is an east-west collector street while 6th Street West is a local north-south, thru street. Their intersection is located one block west of 5th Street West which is a minor arterial. Because of an offset connection at its southern terminus at Central Avenue, a portion of 5th Street West's traffic demand is diverted to 6th Street West. Therefore 6th Street West carries higher traffic volumes than most of the local north-south streets in this area. This intersection is one of three Lewis Avenue intersection sites included in the Lewis Avenue corridor portion of this study.

The primary operational problem noted at this intersection involves sight distance related to perception of the stop condition on 6th Street and intersection sight distance from the stopped position. The Lewis intersection does not provide adequate visual information to warn drivers of its existence nor of the importance of Lewis Avenue to drivers on 6th Street West. To make matters worse, the stop signs are partially obstructed from view by parked cars and pickup trucks.

There were twelve angle accidents at this intersection during the reporting period. Seven of those accidents involved drivers who failed to stop for the stop signs. The two rearend accidents are most likely related to the noted sight distance problems as well. Operational problems with driver expectancy correlate well with the accident history at this intersection.

IMPROVEMENTS

From accident history and operational observations it is felt that pavement markings could be used to enhance the required stop condition on 6th Street. Stop bars and centerline stripes on the two approaches would accomplish this result when the pavement is clear. In addition, 36" stop signs mounted closer to the curb line will help emphasize the stop condition. New advanced warning signs on 6th should replace the existing stop ahead signs. Increased parking restrictions are critical to obtain necessary crossing and approach vehicle sight distance requirements. The new restrictions should be appropriately signed. Painted yellow curb in the new restricted areas will also reduce the chance of vehicles obstructing the line of sight.

LEWIS AVENUE & 6TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1900
SOUTH APP	2200
EAST APP	7700
WEST APP	7300

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
WARNING	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$2,000
MDoT FUND	$860
CITY FUND	$1,140

% ACCIDENT REDUCTION:

INJ/FTL	50%
PDO	46%

BENEFIT/COST RATIO: 21

	INDEX VALUE	SITE RANK
# ACCIDENTS	79	7
ACCIDENT RATE	33	16
SEVERITY	47	9
VOL/CAPACITY	50	9
SIGHT DIST.	100	9
DRIVER EXPECT	71	8
INFO DEFICIENT	58	20
HAZARD INDEX	57.9	10
B/C RATIO	66	11

PRIORITY	60.57	9

SITE

NUMBER

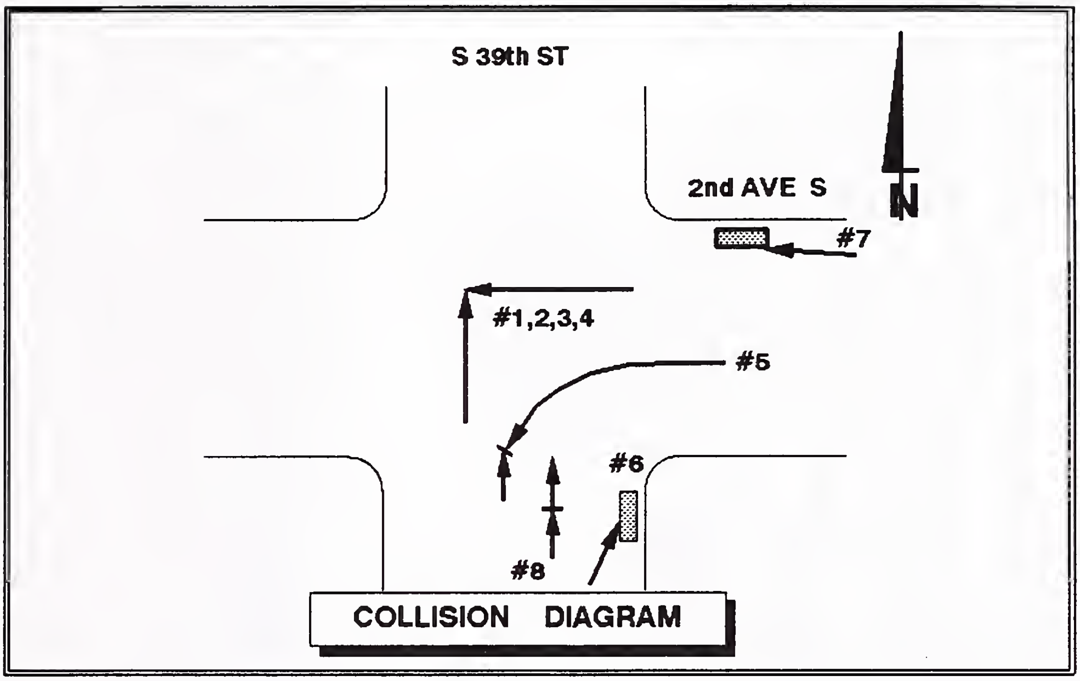
10

SECOND AVENUE S.

and

S. 39TH STREET

ACCIDENT SUMMARY
SECOND AVE S & S 39TH STREET



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	1	4	88	1644	PROP DAM	CLEAR	ICY	NITE
2	ANGLE	2	3	89	748	PROP DAM	CLEAR	SNOW	DAY
3	ANGLE	2	14	89	1727	PROP DAM	CLEAR	ICY	DAY
4	ANGLE	3	19	89	1515	INJURY	CLEAR	ICY	DAY
5	HEAD ON	4	5	91	1825	PROP DAM	CLEAR	DRY	DAY
6	PARKED CAR	1	3	88	28	PROP DAM	CLEAR	SNOW	NITE
7	PARKED CAR	5	19	89	1515	PROP DAM	CLEAR	DRY	DAY
8	REAREND	2	2	88	1556	INJURY	CLEAR	ICY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
3	1988	NO. INJURY	2
3	1989	NO. FATAL	0
1	1990	NO. PDO	6
1	1991	PER INJ=	2
8	TOTAL	NIGHTIME	25%

TYPES	NUMBER	ROAD	
ANGLE	4	DRY	25%
REAR END	1	WET	0%
SIDESWIPE	0	SNOW	25%
LEFT TRN	0	ICE	50%
OTHER	3	OTHER	0%

S. 39TH ST. LOOKING NORTH

S 39TH ST. LOOKING SOUTH

SECOND AVE. S. LOOKING EAST

SECOND AVE. S. LOOKING WEST

TRAFFIC OPERATIONS

Second Avenue S. and S. 39th Street are two local streets in a residential neighborhood on the south end of Billings. S. 39th Street is also one of several north-south streets that serve as a connector between two arterial streets, State Avenue and 1st Avenue South. Because these arterial streets intersect in a wye approximately 1/4 mile west of this intersection, several of the local cross streets, serve cross traffic between them. Thus, traffic volumes are higher in a north-south direction. This intersection is also within one block of an intersection with 1st Avenue South. Vehicles entering the intersection from the 1st Avenue S. side tend to assume right of way in their favor because they have just exited an arterial. Northbound traffic also enters the intersection without proper attention to potential conflicts to cross traffic because of a visual sense created by large grain silos directly in line with N. 30th at 1st Avenue South. Drivers' attention is drawn to the impending stop at the T-intersection. There were four angle accidents at this intersection during the reporting period. All of these accidents involved northbound and westbound vehicles where there are no permanent sight restrictions.

IMPROVEMENTS

It is apparent that driver habit is controlling operations at this intersection. Most of the accidents involved local residents who undoubtedly use this intersection quite frequently. Accidents occur when the assumed direction of travel by approaching vehicles does not meet the drivers' expectancy. Other drivers not as familiar with this intersection are more attentive to potential conflicts and are sometimes confused by lack of control. In addition, 75% of the accidents occurred on wet or icy roads. If speeds on any of the approaches were lower it may have resulted in fewer accidents in these instances.

Because of relatively low traffic volumes and the directional flow of traffic at this intersection, it is recommended that yield signs be installed on the Second Avenue N. approach legs of this intersection. This control is expected to provide more reaction time when road conditions are less than ideal and provide a clear indication of vehicular right of way.

SECOND AVENUE S & S. 39TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1500
SOUTH APP	1500
EAST APP	550
WEST APP	700

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	YES
STOP	
SIGNAL	
MARKING	YES
GUIDANCE	
REGULATORY	

ESTIMATED COST:

TOTAL	$360
MDoT FUND	$200
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	50%
PDO	33%

BENEFIT/COST RATIO: 52

	INDEX VALUE	SITE RANK
# ACCIDENTS	61	23
ACCIDENT RATE	61	6
SEVERITY	46	13
VOL/CAPACITY	13	22
SIGHT DIST.	13	24
DRIVER EXPECT	50	23
INFO DEFICIENT	50	24
HAZARD INDEX	47.5	25
B/C RATIO	86	5

PRIORITY	60.21	10

SITE

NUMBER

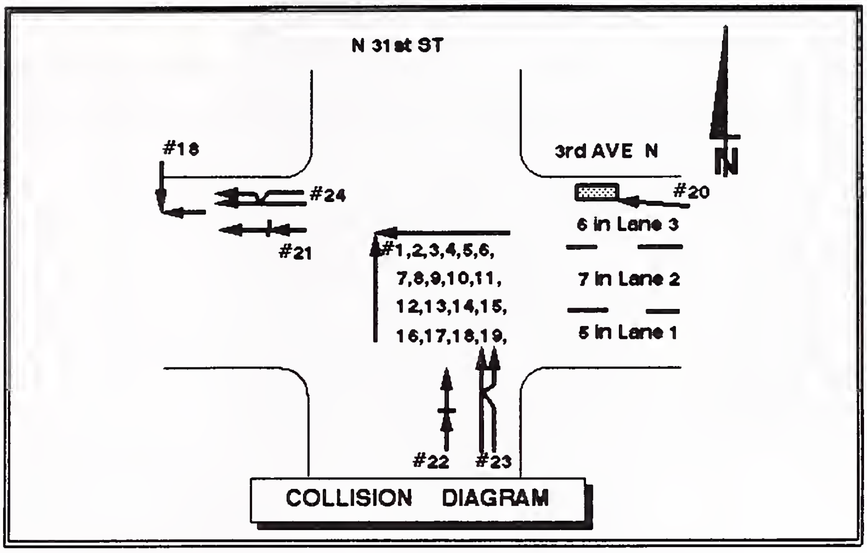
11

THIRD AVENUE N.

and

N. 31ST STREET

ACCIDENT SUMMARY
THIRD AVE N & N 31ST STREET



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	3	8	88	1105	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	4	8	88	1621	INJURY	CLEAR	DRY	DAY
3	ANGLE	8	19	88	1012	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	12	13	88	1817	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	12	16	88	913	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	2	22	89	1307	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	3	8	89	1101	PROP DAM	CLEAR	DRY	DAY
8	ANGLE	10	12	89	1013	PROP DAM	CLEAR	DRY	DAY
9	ANGLE	1	11	90	1517	PROP DAM	CLEAR	DRY	DAY
10	ANGLE	2	13	90	1918	INJURY	CLEAR	SNOW	NITE
11	ANGLE	4	2	90	1625	PROP DAM	CLEAR	DRY	DAY
12	ANGLE	4	24	90	1422	PROP DAM	CLEAR	DRY	DAY
13	ANGLE	7	3	90	1208	PROP DAM	CLEAR	DRY	DAY
14	ANGLE	7	16	90	1343	PROP DAM	CLEAR	DRY	DAY
15	ANGLE	12	21	90	1139	PROP DAM	CLEAR	ICY	DAY
18	ANGLE	1	4	91	1251	PROP DAM	CLEAR	ICY	DAY
17	ANGLE	1	11	91	2230	PROP DAM	CLEAR	ICY	NITE
18	ANGLE	2	5	91	1420	PROP DAM	CLEAR	DRY	DAY
19	ANGLE	4	10	91	1304	INJURY	SNOW	WET	DAY
20	PARKED CAR	11	28	90	1308	PROP DAM	CLEAR	ICY	DAY
21	REAREND	7	8	89	1202	PROP DAM	CLEAR	DRY	DAY
22	REAREND	10	9	89	1330	PROP DAM	CLEAR	DRY	DAY
23	SIDESWIPE	9	29	89	1248	PROP DAM	CLEAR	DRY	DAY
24	SIDESWIPE	7	18	90	1052	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
5	1988	NO. INJURY	3
6	1989	NO. FATAL	0
9	1990	NO. PDO	21
4	1991	PER INJ=	8
24	TOTAL	NIGHTIME	8%

TYPES	NUMBER	ROAD	
ANGLE	19	DRY	75%
REAR END	2	WET	4%
SIDESWIPE	2	SNOW	4%
LEFT TRN	0	ICE	17%
OTHER	1	OTHER	0%

N. 31ST ST. LOOKING NORTH

THIRD AVE. N. LOOKING EAST

THIRD AVE. N. LOOKING WEST

TRAFFIC OPERATIONS

Third Ave N. and N. 31st Streets are two one-way CBD streets. Third Ave is one-way westbound and N. 31st is one-way northbound. Both streets are typical of streets in the CBD since they both have three traffic lanes in a 50' street section with parking on both sides. This intersection is also typical of other CBD intersections in that pedestrian activity requires vehicles to stop well behind the curb radii which limits sight distance along the intersecting street. Since a significant number of intersections in the CBD are signalized, this is not usually a major problem. In this case, northbound traffic is controlled by stop signs. The existence of wide streets, multi-lanes and curb side parking combine to present high probability conditions for angle accidents.

There were 19 angle accidents during the reporting period and two rearend accidents which could be attributed to the above mentioned problems. Four of the angle accidents were confirmed to be vehicles which had stopped before entering the intersection. The remainder either didn't stop completely or blew right through.

IMPROVEMENTS

Because of the relatively high traffic volumes at this intersection a signal warrant analysis was completed. A summary of that analysis can be found at end of this section. None of the signal warrants were met at this intersection. Warrant number 8, combination of warrants was 75% met on the minor leg. Four hour volume and peak hour volume warrants were also close. From this analysis, the only warrant that may be met is the accident experience warrant. However, other improvements must be tried prior to installing a signal based on that warrant.

The only viable improvements that would prove to have measurable effectiveness would be ones which increase the intersection sight distance for the stop street. A dynamic vehicle model using average acceleration rate for a single unit design vehicle was used to calculate critical gaps and required

sight distance. Based on this analysis, parking would have to be removed for a half block to attain required sight distance and this intersection is located in an area where parking is at a premium. As an alternative,bulb island curbs on the south side of the street was evaluated. Because this alternative would only remove 2 parking spaces; reduce the critical vehicular crossing gap; reduce the width of crossing for pedestrians; and provide an improved location to mount stop signs, it is the recommended improvement. New stop signs should be oversized to catch drivers attention which is important at this location where drivers are required to monitor a number of different activities beyond navigation. Better alignment of the lane markings on the 31st Street approach and thru the intersection along with plastic words and symbols will also help confusion and decrease driver information load.

These improvements are more costly than other short term improvements, but the expected benefits are high. Reconstruction of the curb line may also provide opportunities for street scape improvements if the City would so desire.

THIRD AVENUE N. & N. 31ST STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	2800
SOUTH APP	2200
EAST APP	9400
WEST APP	9100

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
GUIDANCE	
CONSTRUCT.	YES

ESTIMATED COST:

TOTAL	$9470
MDoT FUND	$280
CITY FUND	$8,770

% ACCIDENT REDUCTION:

INJ/FTL	70%
PDO	57%

BENEFIT/COST RATIO: 16

	INDEX VALUE	SITE RANK
# ACCIDENTS	90	1
ACCIDENT RATE	38	14
SEVERITY	47	10
VOL/CAPACITY	33	13
SIGHT DIST.	100	1
DRIVER EXPECT	75	7
INFO DEFICIENT	58	17
HAZARD INDEX	60	4
B/C RATIO	60	13

PRIORITY	60.00	11

TRAFFIC SIGNAL WARRANT ANALYSIS
YEAR 1991
THIRD AVENUE N. & N. 31ST STREET

WARRANT #1 - MINIMUM VEHICULAR VOLUME					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		600	200	570	120
% OF WARRANT MET				95%	60%

WARRANT #2 - INTERRUPTION OF CONTINOUS TRAFFIC					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		900	100	570	120
% OF WARRANT MET				63%	120%

WARRANT #3 - MINIMUM PEDESTRIAN TRAFFIC					
50% WARRANT		REQUIRED		EXISTS	
YES	NO	PEDS	GAPS	PEDS	GAPS
FOUR HOURS		100	60	15	90
PEAK HOUR		190	60	23	60
% OF WARRANT MET				12%	100%

WARRANT #4 - SCHOOL CROSSING [STUD	YES	NO
WARRANT #5 - PROGRESSIVE MOVEMENT	YES	NO
WARRANT #6 - ACCIDENT EXPERIENCE	YES	NO
WARRANT #7 - SYSTEMS WARRANT	YES	NO

WARRANT #8 - COMBINATION OF WARRANTS				
80 % OF	REQUIRED		EXISTS	
WARRANTS #1 & #2	MAJOR	MINOR	MAJOR	MINOR
WARRANT #1	480	160	570	120
WARRANT #2	720	80	570	120
% OF WARRANT MET			99%	75%

WARRANT #9 - FOUR HOUR VOLUMES				
	MAJOR	MINOR	CURVE NO.	WARRAN
4TH HIGHEST HOUR	680	150	FIGURE	YES
NUMBER OF LANES	2	2	4.7	NO

WARRANT #10 - PEAK HOUR DELAY				
PEAK HOUR:	MINOR LEG		TOTAL ENTERING	
	DELAY	VOLUME	4 LEGS	3 LEGS
REQUIRED VALUES	4	100	800	650
EXISTING VALUES	2.4	200	1100	

WARRANT #11 - PEAK HOUR VOLUME				
	MAJOR	MINOR	CURVE NO.	WARRAN
PEAK HOUR	900	200	FIGURE	YES
NUMBER OF LANES	1	1	4.5	NO

SUMMARY OF WARRANTS SATISFIED					
WARRANT 1		WARRANT 5		WARRANT 9	
WARRANT 2		WARRANT 6		WARRANT 10	
WARRANT 3		WARRANT 7		WARRANT 11	
WARRANT 4		WARRANT 8		TOTAL =	0

SITE

NUMBER

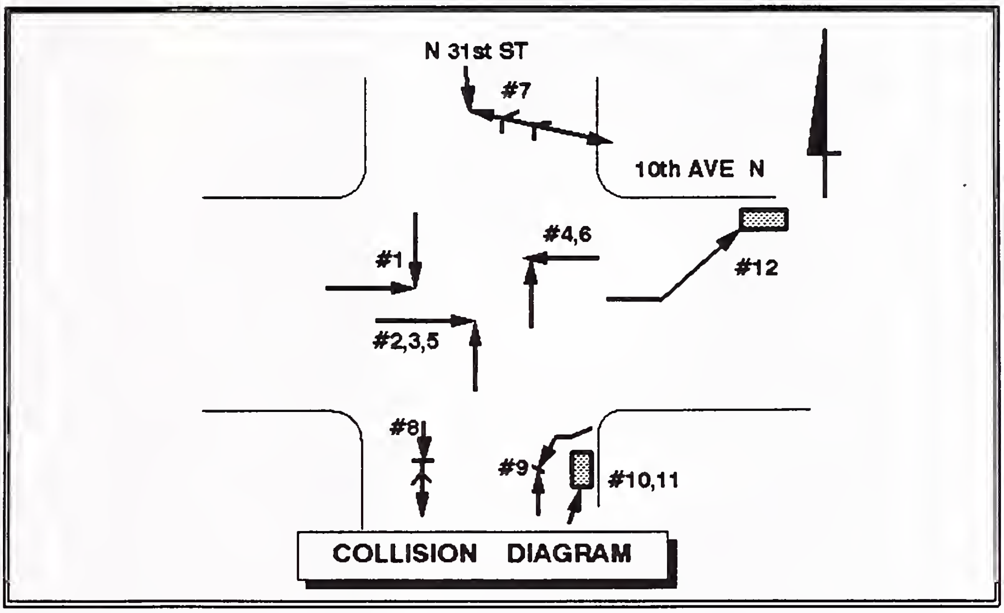
12

TENTH AVENUE N.

and

N. 31ST STREET

ACCIDENT SUMMARY
TENTH AVE N & N 31ST STREET



ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
		ACCIDENT KEY							
1	ANGLE	3	19	89	1803	PROP DAM	CLEAR	ICY	DAY
2	ANGLE	1	22	90	1120	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	2	16	90	1602	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	4	4	90	808	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	11	18	90	1653	INJURY	CLEAR	DRY	DAY
6	ANGLE	11	26	90	723	PROP DAM	CLEAR	DRY	DAY
7	BACKING	2	5	88	1625	PROP DAM	CLEAR	DRY	DAY
8	BACKING	2	13	88	846	PROP DAM	CLEAR	ICY	DAY
9	HEAD ON	12	11	89	933	PROP DAM	CLEAR	SNOW	DAY
10	PARKED CAR	2	20	90	1320	PROP DAM	CLEAR	DRY	DAY
11	PARKED CAR	8	10	90	1226	PROP DAM	CLEAR	DRY	DAY
12	PARKED CAR	12	12	90	1314	PROP DAM	SNOW	ICY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	1
2	1989	NO. FATAL	0
8	1990	NO. PDO	11
0	1991	PER INJ=	1
12	TOTAL	NIGHTIME	0%

TYPES	NUMBER	ROAD	
ANGLE	6	DRY	46%
REAREND	0	WET	0%
SIDESWIPE	0	SNOW	17%
LEFT TRN	0	ICE	38%
OTHER	6	OTHER	0%

N. 31ST ST. LOOKING NORTH

N. 31ST ST. LOOKING SOUTH

TENTH AVE. N. LOOKING EAST

TENTH AVE. N. LOOKING WEST

TRAFFIC OPERATIONS

Tenth Avenue N. and N. 31st Street are local streets within a residential neighborhood on the fringe of the Medical Corridor area. They are narrow two lane streets with parking on both sides. When vehicles are parked on these 31' streets, there is barely enough room for two vehicles to pass. Fortunately, traffic volumes are low. There were six angle accidents at this intersection during the reporting period along with 6 other accident types which reflect the narrow street conditions.

IMPROVEMENTS

It would be difficult to devise short term improvements at this intersection which would significantly affect accident experience because of the restrictive geometry. Vehicular right of way control would not be considered reasonable because of equally low approach volumes on all legs. There is evidence that vehicles park near the corners and therefore, the least costly solution with the most potential benefit may be parking restrictions at the intersection corners. This should be accomplished by painting the curbs yellow. Because all but one of the angle accidents involved northbound vehicles, parking restrictions on the south side of the intersection should also be signed to reinforce these restrictions.

TENTH AVENUE N & N. 31ST STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	750
SOUTH APP	750
EAST APP	900
WEST APP	800

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$560
MDoT FUND	$400
CITY FUND	$160

% ACCIDENT REDUCTION:

INJ/FTL	30%
PDO	25%

BENEFIT/COST RATIO: 16

	INDEX VALUE	SITE RANK
# ACCIDENTS	72	16
ACCIDENT RATE	93	2
SEVERITY	39	23
VOL/CAPACITY	17	20
SIGHT DIST.	32	19
DRIVER EXPECT	58	17
INFO DEFICIENT	58	21
HAZARD INDEX	59	6
B/C RATIO	61	12

PRIORITY	59.66	12

SITE

NUMBER

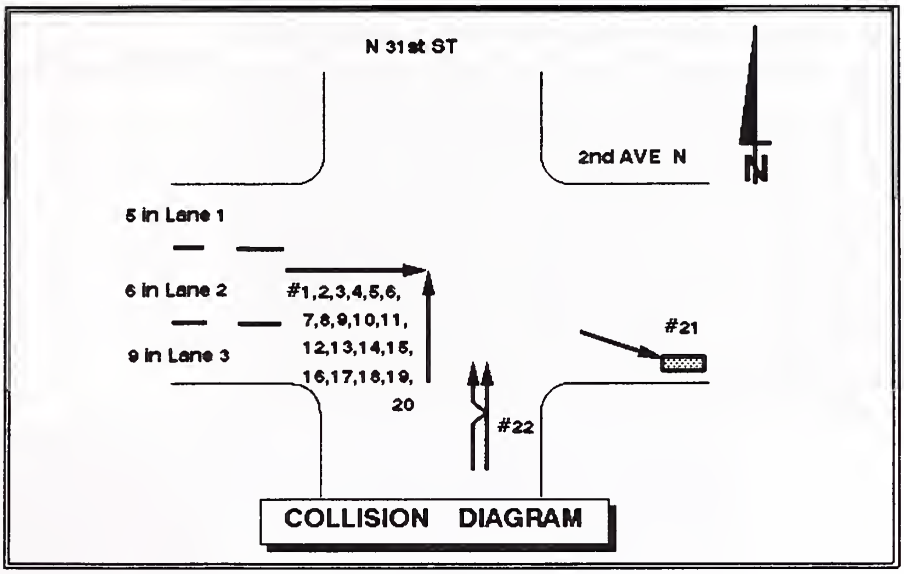
13

SECOND AVENUE N.

and

N. 31ST STREET

ACCIDENT SUMMARY
SECOND AVE N & N 31ST STREET



ACC NO.	ACCIDENT TYPE	ACCIDENT KEY MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	1	4	88	1239	PROP DAM	CLEAR	ICY	NITE
2	ANGLE	4	26	88	1710	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	6	24	88	1809	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	10	4	88	1617	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	10	5	88	1457	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	11	5	88	1302	INJURY	CLEAR	DRY	DAY
7	ANGLE	1	3	89	1012	INJURY	CLEAR	DRY	DAY
8	ANGLE	4	12	89	1150	INJURY	CLEAR	DRY	DAY
9	ANGLE	4	21	89	2229	PROP DAM	CLEAR	DRY	NITE
10	ANGLE	5	3	89	1124	INJURY	RAIN	WET	DAY
11	ANGLE	8	25	89	1558	PROP DAM	CLEAR	DRY	DAY
12	ANGLE	9	25	89	1555	PROP DAM	CLEAR	DRY	DAY
13	ANGLE	1	9	90	1329	PROP DAM	CLEAR	DRY	DAY
14	ANGLE	8	7	90	636	PROP DAM	CLEAR	DRY	DAY
15	ANGLE	9	21	90	1514	PROP DAM	CLEAR	DRY	DAY
16	ANGLE	9	26	90	1511	PROP DAM	CLEAR	DRY	DAY
17	ANGLE	10	8	90	1127	PROP DAM	CLEAR	DRY	DAY
18	ANGLE	10	29	90	854	PROP DAM	CLEAR	DRY	DAY
19	ANGLE	2	25	91	1645	PROP DAM	CLEAR	DRY	DAY
20	ANGLE	2	28	91	1339	PROP DAM	CLEAR	DRY	DAY
21	PARKED CAR	4	5	88	2000	PROP DAM	CLEAR	DRY	NITE
22	SIDESWIPE	1	4	91	1215	PROP DAM	CLEAR	SNOW	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
7	1988	NO. INJURY	4
6	1989	NO. FATAL	0
6	1990	NO. PDO	18
3	1991	PER INJ=	4
22	TOTAL	NIGHTIME	9%

TYPES	NUMBER	ROAD	
ANGLE	20	DRY	86%
REAR END	1	WET	5%
SIDESWIPE	0	SNOW	5%
LEFT TRN	0	ICE	5%
OTHER	1	OTHER	0%

N. 31ST ST. LOOKING NORTH

SECOND AVE. N. LOOKING EAS

SECOND AVE. N. LOOKING WEST

TRAFFIC OPERATIONS

Second Ave N. and N. 31st Streets are two one-way CBD streets. Second Avenue is one-way eastbound and N. 31st is one-way northbound. Both streets are typical of streets in the CBD since they both have three traffic lanes in a 50' street section with parking on both sides. This intersection is also typical of other CBD intersections in that pedestrian activity requires vehicles to stop well behind the curb radii which limits sight distance along the intersecting street. Since a significant number of intersections in the CBD are signalized, this is not usually a major problem. In this case, northbound traffic is controlled by stop signs. The existence of wide streets, multi-lanes and curb side parking combine to present high probability conditions for angle accidents.

There were 20 angle accidents during the reporting period and only two other types of accidents at this intersection. Four of the angle accidents were confirmed to be vehicles which had stopped before entering the intersection. The remainder either didn't stop completely or blew right through.

IMPROVEMENTS

Because of the relatively high traffic volumes at this intersection a signal warrant analysis was completed. A summary of that analysis can be found at end of this section. None of the signal warrants were met at this intersection. Warrant number 8, combination of warrants was 61% met on the major leg. From this analysis, the only warrant that may be met is the accident experience warrant. However, other improvements must be tried prior to installing a signal based on that warrant.

The only viable improvements that would prove to have measurable effectiveness would be one which increases the intersection sight distance for the stop street. A dynamic vehicle model using average acceleration rate for a single unit design vehicle was used to calculate critical gaps and required

sight distance. Based on this analysis, parking would have to be removed for a half block to attain required sight distance and this intersection is located in an area where parking is at a premium. As an alternative,bulb island curbs on the south side of the street was evaluated. Because this alternative would only remove 2 parking spaces; reduce the critical vehicular crossing gap; reduce the width of crossing for pedestrians; and provide an improved location to mount stop signs, it is the recommended improvement. New stop signs should be oversized to catch drivers attention which is important at this location where drivers are required to monitor a number of different activities beyond navigation.

These improvements are more costly than other short term improvements, but the expected benefits are high. Reconstruction of the curb line may also provide opportunities for street scape improvements if the City would so desire.

In addition to the above, the City should investigate whether they are able to have the tall metal poles, which surround the lot in the southwest corner, removed. Their presence is visually distracting to drivers on the 31st Street approach. Also, the 8 hour parking meters on the west side of the intersection could be swapped with the two hour meters on the east side. In this area, the parking demand on the west side would then be reduced.

SECOND AVENUE N & N. 31ST STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1700
SOUTH APP	2300
EAST APP	6400
WEST APP	5800

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
WARNING	
CONSTRUCT.	YES

ESTIMATED COST:

TOTAL	$8,200
MDoT FUND	$480
CITY FUND	$7,720

% ACCIDENT REDUCTION:

INJ/FTL	65%
PDO	61%

BENEFIT/COST RATIO: 12

	INDEX VALUE	SITE RANK
# ACCIDENTS	87	3
ACCIDENT RATE	48	11
SEVERITY	43	18
VOL/CAPACITY	29	15
SIGHT DIST.	100	5
DRIVER EXPECT	67	14
INFO DEFICIENT	75	2
HAZARD INDEX	61.4	2
B/C RATIO	54	15

PRIORITY	58.96	13

TRAFFIC SIGNAL WARRANT ANALYSIS
YEAR 1991
SECOND AVENUE N. & N. 31ST STREET

WARRANT #1 - MINIMUM VEHICULAR VOLUME					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		600	200	350	140
% OF WARRANT MET				58%	70%

WARRANT #2 - INTERRUPTION OF CONTINOUS TRAFFIC					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		900	100	350	140
% OF WARRANT MET				39%	140%

WARRANT #3 - MINIMUM PEDESTRIAN TRAFFIC					
50% WARRANT		REQUIRED		EXISTS	
YES	NO	PEDS	GAPS	PEDS	GAPS
FOUR HOURS		100	60	20	100
PEAK HOUR		190	60	40	65
% OF WARRANT MET				21%	92%

WARRANT #4 - SCHOOL CROSSING [STUD	YES	NO

WARRANT #5 - PROGRESSIVE MOVEMENT	YES	NO

WARRANT #6 - ACCIDENT EXPERIENCE	YES	NO

WARRANT #7 - SYSTEMS WARRANT	YES	NO

WARRANT #8 - COMBINATION OF WARRANTS				
80 % OF	REQUIRED		EXISTS	
WARRANTS #1 & #2	MAJOR	MINOR	MAJOR	MINOR
WARRANT #1	480	160	350	140
WARRANT #2	720	80	350	140
% OF WARRANT MET			61%	131%

WARRANT #9 - FOUR HOUR VOLUMES				
	MAJOR	MINOR	CURVE NO.	WARRAN
4TH HIGHEST HOUR	420	170	FIGURE	YES
NUMBER OF LANES	2	2	4.7	NO

WARRANT #10 - PEAK HOUR DELAY				
PEAK HOUR:	MINOR LEG		TOTAL ENTERING	
	DELAY	VOLUME	4 LEGS	3 LEGS
REQUIRED VALUES	4	100	800	650
EXISTING VALUES	1	230	800	

WARRANT #11 - PEAK HOUR VOLUME				
	MAJOR	MINOR	CURVE NO.	WARRAN
PEAK HOUR	580	230	FIGURE	YES
NUMBER OF LANES	1	1	4.5	NO

SUMMARY OF WARRANTS SATISFIED					
WARRANT 1		WARRANT 5		WARRANT 9	
WARRANT 2		WARRANT 6		WARRANT 10	
WARRANT 3		WARRANT 7		WARRANT 11	
WARRANT 4		WARRANT 8		TOTAL =	0

SITE

NUMBER

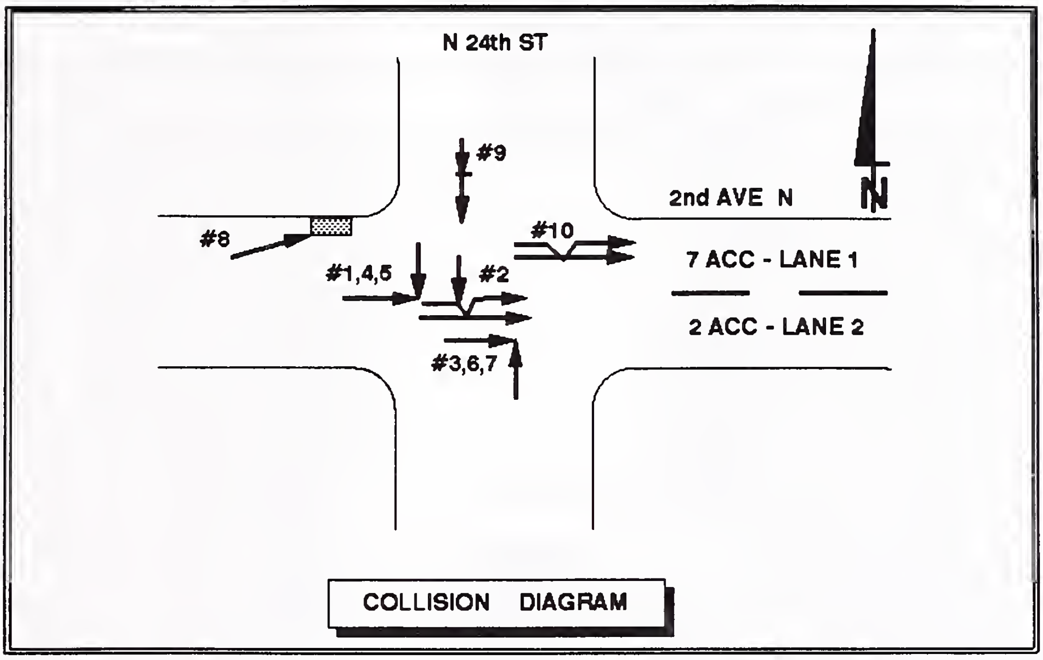
14

SECOND AVENUE N.

and

N. 24TH STREET

ACCIDENT SUMMARY
SECOND AVE N & N 24TH STREET



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	1	9	88	2015	PROP DAM	CLEAR	DRY	NITE
2	ANGLE	3	3	89	1347	PROP DAM	CLEAR	ICY	DAY
3	ANGLE	3	14	89	1447	PROP DAM	CLEAR	ICY	DAY
4	ANGLE	3	29	90	1717	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	8	3	90	1644	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	3	2	91	1646	INJURY	CLEAR	DRY	DAY
7	ANGLE	3	12	91	957	PROP DAM	CLEAR	DRY	DAY
8	PARKED CAR	3	4	91	2024	PROP DAM	CLEAR	DRY	NITE
9	REAREND	5	22	89	1245	PROP DAM	CLEAR	DRY	DAY
10	SIDESWIPE	8	6	88	1439	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	1
3	1989	NO. FATAL	0
2	1990	NO. PDO	9
3	1991	PER INJ=	2
10	TOTAL	NIGHTIME	20%

TYPES	NUMBER	ROAD	
ANGLE	7	DRY	80%
REAR END	1	WET	0%
SIDESWIPE	1	SNOW	0%
BIKE/PED	0	ICE	20%
OTHER	1	OTHER	0%

N. 24TH ST. LOOKING NORTH

N. 24TH ST. LOOKING SOUTH

SECOND AVE N LOOKING EAST

SECOND AVE N LOOKING WEST

TRAFFIC OPERATIONS

Second Ave N. is a one-way eastbound street which traverses the CBD. North 24th Street is a two-way street located near the eastern fringe of the CBD area. Second Avenue North, despite a 51' street width, only carries two lanes of traffic and parking is allowed on both sides. North 24th Street is also 51' wide and carries two thru lanes with parking. There are insufficient traffic volumes at this intersection to justify exclusive turn lanes.

The most obvious problems at this intersection involves sight distance and lack of driver information. Both the northwest and southwest corners of this intersection have large buildings located right at the property line. Because of limited pedestrian activity vehicles can stop within the curb radii areas prior to entering the intersection, but parked vehicles restrict sight distance even at that point. In addition, stop signs are not readily noticeable on N. 24th Street, especially on the northbound approach.

There were 7 angle accidents during the reporting period. Only one of the angle accidents were confirmed to be vehicles which had stopped before entering the intersection. The remainder either didn't stop completely or blew right through.

IMPROVEMENTS

It is apparent that sight distance improvements are required at this intersection. A dynamic vehicle model using average acceleration rate for a single unit design vehicle was used to calculate critical gaps and required sight distance. Based on this analysis, parking would have to be removed for a distance of 60 feet on 2nd Avenue west of the intersection to provide minimum sight distance. The parking restrictions should be signed and curbs painted yellow to emphasize these zone restrictions. Yellow curb paint 30' in advance of the northbound stop sign is also recommended. New stop signs should be oversized to catch drivers attention. The new sign in the southeast corner should be located closer to the curb using a cantilever mounting. In addition, stop bars and centerline markings should be painted on the N. 24th approaches to provide additonal reinforcement of the stop condition.

SECOND AVENUE N & N. 24TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1500
SOUTH APP	1500
EAST APP	3500
WEST APP	4200

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$880
MDoT FUND	$480
CITY FUND	$400

% ACCIDENT REDUCTION:

INJ/FTL	60%
PDO	44%

BENEFIT/COST RATIO: 28

	INDEX VALUE	SITE RANK
# ACCIDENTS	67	20
ACCIDENT RATE	36	15
SEVERITY	45	14
VOL/CAPACITY	28	16
SIGHT DIST.	100	2
DRIVER EXPECT	50	24
INFO DEFICIENT	61	14
HAZARD INDEX	51.6	20
B/C RATIO	73	9

PRIORITY	58.80	14

SITE

NUMBER

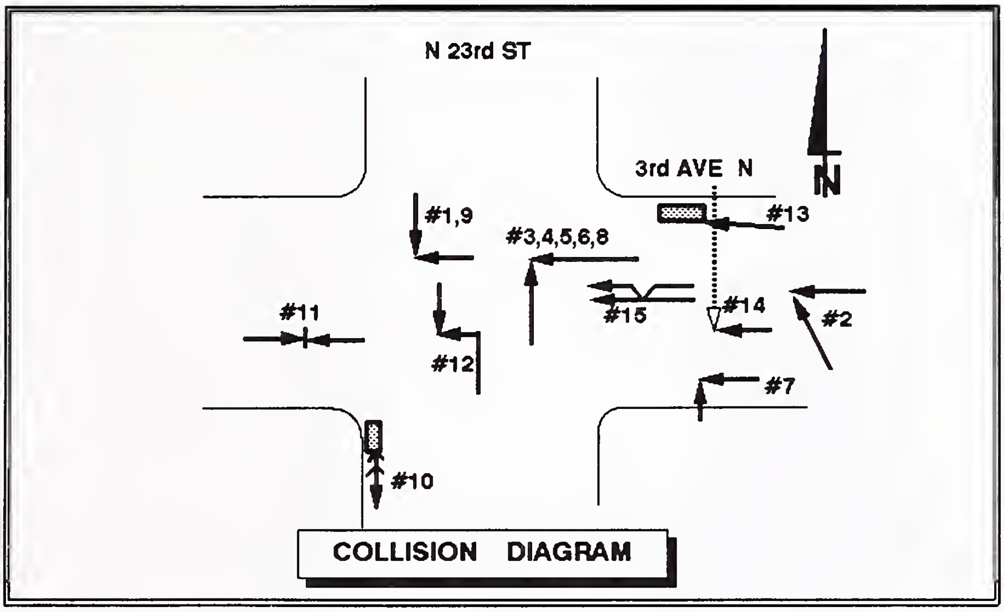
15

THIRD AVENUE N.

and

N. 23RD STREET

ACCIDENT SUMMARY
THIRD AVE N & N 23RD STREET



ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	2	1	88	1026	INJURY	CLEAR	SNOW	DAY
2	ANGLE	1	24	89	1320	PROP DAM	CLEAR	SNOW	DAY
3	ANGLE	4	15	89	1922	INJURY	CLEAR	DRY	NITE
4	ANGLE	10	17	89	1328	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	12	17	89	1511	PROP DAM	CLEAR	SNOW	DAY
6	ANGLE	1	15	90	1211	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	7	30	90	1702	PROP DAM	CLEAR	DRY	DAY
8	ANGLE	9	17	90	1244	PROP DAM	CLEAR	DRY	DAY
9	ANGLE	12	14	90	1111	PROP DAM	SNOW	SNOW	DAY
10	BACKING	11	17	90	2127	PROP DAM	CLEAR	DRY	NITE
11	HEAD ON	10	16	88	152	PROP DAM	CLEAR	DRY	NITE
12	LEFT TURN	11	3	88	1309	PROP DAM	CLEAR	DRY	DAY
13	PARKED CAR	4	30	89	740	PROP DAM	CLEAR	DRY	NITE
14	PEDESTRIAN	5	5	88	754	INJURY	CLEAR	DRY	DAY
15	SIDESWIPE	4	20	88	1452	PROP DAM	CLEAR	DRY	DAY

ACCIDENT KEY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
5	1988	NO. INJURY	3
5	1989	NO. FATAL	0
5	1990	NO. PDO	12
0	1991	PER INJ=	3
15	TOTAL	NIGHTIME	27%

TYPES	NUMBER	ROAD	
ANGLE	9	DRY	73%
PEDESTRIA	1	WET	0%
SIDESWIPE	1	SNOW	27%
LEFT TRN	1	ICE	0%
OTHER	3	OTHER	0%

N. 23RD ST. LOOKING NORTH

N. 23RD ST. LOOKING SOUTH

THIRD AVE. N LOOKING EAST

THIRD AVE. NORTH LOOKING WEST

TRAFFIC OPERATIONS

Third Ave N. is a one-way westbound street which traverses the CBD. North 23rd Street is a two-way street located near the eastern fringe of the CBD area. Third Avenue North, despite a 51' street width, only carries two lanes of traffic and parking is allowed on both sides. North 23rd Street is also 51' wide and carries two thru lanes with parking. There is insufficient traffic volumes at this intersection to justify exclusive turn lanes.

The most obvious problem at this intersection involves sight distances and lack of driver information. Because of limited pedestrian activity vehicles can stop within the curb radii areas prior to entering the intersection, but parked vehicles restrict sight distance even at that point. In addition, stop signs are not readily noticeable on N. 23rd Street, especially on the northbound approach.

There were 9 angle accidents during the reporting period. Only one of the angle accidents were confirmed to be vehicles which had stopped before entering the intersection. The remainder either didn't stop completely or blew right through. One accident involved a pedestrian walking from behind a parked car on 3rd just east of the intersection. Twenty seven percent of the accidents were during hours of darkness. There is currently lighting at the intersection, it should be monitored in the future to see if there is a problem.

IMPROVEMENTS

It is apparent that sight distance improvements are required at this intersection. A dynamic vehicle model using average acceleration rate for a single unit design vehicle was used to calculate critical gaps and required sight distance. Based on this analysis, parking would have to be removed for a distance of 70 feet on 2nd Avenue east of the intersection to provide minimum sight distance. The parking restrictions should be signed and the parking area blocked out with cross hatch markings to guide vehicles through the westbound approach lanes. Yellow curb paint 30' in advance of the 23rd Street stop signs is also recommended. New stop signs should be oversized to catch drivers attention. In addition, stop bars, crosswalks and centerline striping should be painted on the side street approaches to provide additional clues as to the stop condition.

THIRD AVENUE N. & N. 23RD STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1100
SOUTH APP	850
EAST APP	3400
WEST APP	3600

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$1,890
MDoT FUND	$480
CITY FUND	$1,410

% ACCIDENT REDUCTION:

INJ/FTL	47%
PDO	33%

BENEFIT/COST RATIO: 15

	INDEX VALUE	SITE RANK
# ACCIDENTS	78	10
ACCIDENT RATE	56	8
SEVERITY	44	16
VOL/CAPACITY	21	17
SIGHT DIST.	100	8
DRIVER EXPECT	39	25
INFO DEFICIENT	44	25
HAZARD INDEX	53.6	17
B/C RATIO	59	14

PRIORITY	55.38	15

SITE

NUMBER

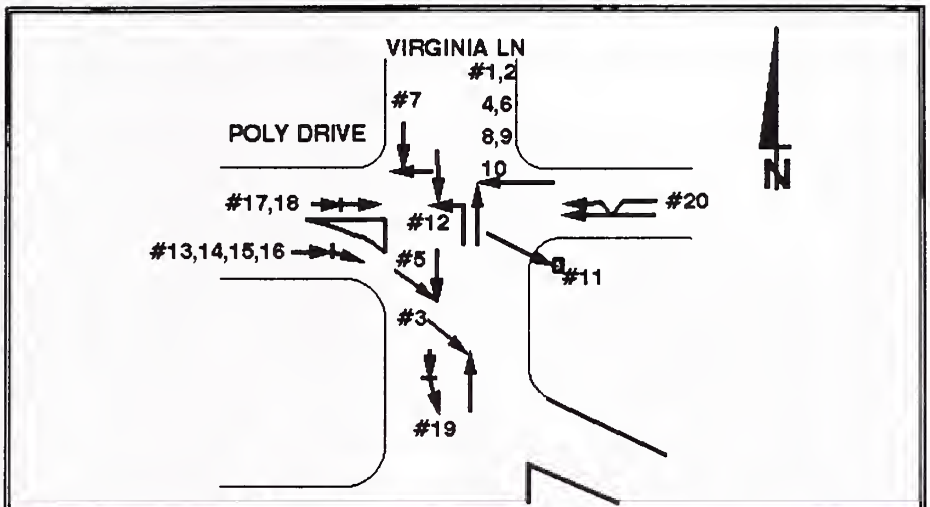
16

POLY DRIVE

and

VIRGINIA LANE

ACCIDENT SUMMARY
POLY DRIVE & VIRGINIA LN



COLLISION DIAGRAM

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
		ACCIDENT KEY							
1	ANGLE	1	2	88	1102	PROP DAM	CLEAR	ICY	DAY
2	ANGLE	8	21	88	1826	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	8	25	88	1812	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	4	21	89	151	PROP DAM	CLEAR	DRY	NITE
5	ANGLE	6	6	89	1011	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	7	27	89	1251	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	7	17	90	1308	INJURY	CLEAR	DRY	DAY
8	ANGLE	11	22	90	1411	INJURY	CLEAR	DRY	DAY
9	ANGLE	1	27	91	1706	PROP DAM	CLEAR	SNOW	NITE
10	ANGLE	3	30	91	1209	PROP DAM	CLEAR	DRY	DAY
11	FIXED OBJ	9	14	88	2303	PROP DAM	CLEAR	DRY	NITE
12	LEFT TURN	4	14	89	1900	PROP DAM	CLEAR	DRY	DAY
13	REAREND	1	8	88	1506	PROP DAM	CLEAR	ICY	DAY
14	REAREND	1	28	89	1334	PROP DAM	CLEAR	ICY	DAY
15	REAREND	2	28	89	1119	PROP DAM	SNOW	SNOW	DAY
16	REAREND	3	21	89	808	PROP DAM	CLEAR	ICY	DAY
17	REAREND	2	10	90	1530	PROP DAM	CLEAR	WET	DAY
18	REAREND	4	6	90	732	PROP DAM	CLEAR	DRY	DAY
19	REAREND	5	22	90	946	INJURY	CLEAR	DRY	DAY
20	SIDESWIPE	2	4	88	1118	PROP DAM	SNOW	SNOW	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
6	1988	NO. INJURY	3
7	1989	NO. FATAL	0
5	1990	NO. PDO	17
2	1991	PER INJ=	3
20	TOTAL	NIGHTIME	15%

TYPES	NUMBER	ROAD	
ANGLE	10	DRY	60%
REAR END	7	WET	5%
SIDESWIPE	1	SNOW	15%
LEFT TRN	1	ICE	20%
OTHER	1	OTHER	0%


VIRGINIA LANE LOOKING NORTH


VIRGINIA LANE LOOKING SOUTH

POLY DRIVE LOOKING EAST


POLY DRIVE LOOKING WEST

TRAFFIC OPERATIONS

The intersection of Poly Drive and Virginia Lane is a signalized intersection. Unlike all other sites within this study both streets are Federal Aid Urban routes. However, Poly Drive east of Virginia Lane is not classified on the Federal Aid system. The intersection is in the middle of a residential area.
The intersection geometry and traffic control system is highly complex. It was originally constructed in 1973 as part of the old TOPICS program. In 1989, an old narrow bridge on the north side of the intersection was replaced with the existing bridge and approach work was constructed. During that construction, new traffic detectors were installed in the bridge to replace those that had been installed in 1973 which had long since ceased to function. With the 1989 improvements, the City's Traffic Signal Section was able to reprogram signal control at the intersection to take advantage of full signal accuation. Since reprogramming has occurred, the intersection operates many times more efficiently.

There were 10 angle accidents and 7 rearend accidents at this intersection during the reporting period. The accident rate at this intersection is not abnormally high in relationship to signalized intersections in Billings, but the number of accidents is quite high. Observations of the intersection operation indicated that traffic moves through the intersection without many conflicts. The only area of potential conflicts observed was in the trap area between the dual signal indications for north and south traffic. It was also observed that at least one westbound vehicle entered the intersection at the beginning of the red interval on every cycle during peak hours. The only conflict this presents is to vehicles who may have been waiting for a green within the trap area. This situation probably only occurs on every 10th cycle.

The eastbound approach on Poly has some potential problems since speeds are the highest of all approaches and signal indications for those lanes which turn south and east are positioned in such a manner that they are only visible for a distance of 100' in advance of the stop. Signals operating on the same phase for eastbound left traffic can be seen for more than 300 feet and were designed to be seen by all eastbound approach traffic.

Phasing and interval timing was observed during moderate traffic conditions. the signal operates on a three phase cycle with two overlaps. The overlaps are intended to insure that any northbound or southbound vehicles who become trapped between Grandview and Poly will have a separate signal indication to store vehicles until the directional phase is called again. The timing of the overlap is such that most vehicles northbound and southbound will clear the trap area without ever seeing an amber or red indication. However, during periods of extreme congestion or when extremely slow vehicles are in this area, vehicles are stored in this area. There is currently a 5.5 second offset between the first north-south amber and the second or overlap amber.

IMPROVEMENTS

The most consistent angle accident problem seems to be those involving northbound and eastbound traffic. Several recommendations are made to reduce the potential for these accidents. A dynamic vehicle model based on a single unit vehicle (truck or bus) was used to model the northbound movements. It was found that the last car in a northbound queue of vehicles would require 8.0 seconds to leave the southern stop bar and clear the northern intersection. Currently there is 9.5 seconds programmed, including amber and all-red intervals. This only allows 1.5 seconds margin for slower drivers. Slower drivers will likely have to stop for the second set of signals and thus be exposed to that last westbound vehicle which always runs the red. To reduce the possibility of this occurrence, it is recommended that the OLB green interval be increased by 2.0 seconds. As further insurance the westbound all-red interval should be increased by 1 second. In addition, westbound signal indications should be replaced with 12"X12"x12" signal heads to increase driver perception.

In order to reduce rearend accidents occurring in eastbound traffic rearend several other recommendations are made. The existing amber indication is 3.0 seconds. This should be increased to 4.0 seconds. An additional signal head should be added to the island traffic signal pole so that eastbound traffic has a more advanced indication of the hidden signals. The new indication

should be a 12"x12"x12" head. Trees and bushes in the southwest corner should be kept trimmed to improve visibility of the signals in that corner.

Use of the larger signal heads is recommended within this study for specific reasons. The 12"x8"x8" signal indication has been used widely within the past ten to twenty years and rarely is a 12"x12"x12' indication used. There is much controversy over the need for a straight 12" signal head and thus far no statistics are available to support claims either way. A logical examination of their use may shed more light on the subject. A 12" red lens only serves those drivers who have already seen the yellow; those who are already stopped; and those who are approaching and are anticipating the change to green. Twelve inch green lenses improve visibility for those who are approaching the signal by alerting them to the presence of a signal; providing information which can be used to calculate desired speed; and alerting them to the potential for change. The twelve inch yellow improves visibility for approaching drivers and serves to alert them that the red stop condition in imminent and allows them to decide the proper course of action. When these facts are considered, use of a 12" red lense for improved visibility is not nearly as important as use of 12" yellow and green lenses. As far as driver perception and reaction is concerned, need for the red lense is nearly always after the fact. In other words, when the red lense is illuminated, it is too late for any safe action other than to remained stopped.

POLY DRIVE & VIRGINIA LANE

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	5800
SOUTH APP	8100
EAST APP	7700
WEST APP	14500

EXISTING CONTROL:

NONE	
YIELD	
STOP	
SIGNAL	YES

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	
SIGNAL	YES
MARKING	
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$1990
MDoT FUND	$100
CITY FUND	$1,860

% ACCIDENT REDUCTION:

INJ/FTL	27%
PDO	21%

BENEFIT/COST RATIO: 9.2

	INDEX VALUE	SITE RANK
# ACCIDENTS	85	4
ACCIDENT RATE	21	23
SEVERITY	42	19
VOL/CAPACITY	100	2
SIGHT DIST.	31	21
DRIVER EXPECT	83	2
INFO DEFICIENT	71	4
HAZARD INDEX	57.5	12
B/C RATIO	48	17

PRIORITY	54.37	16

SITE

NUMBER

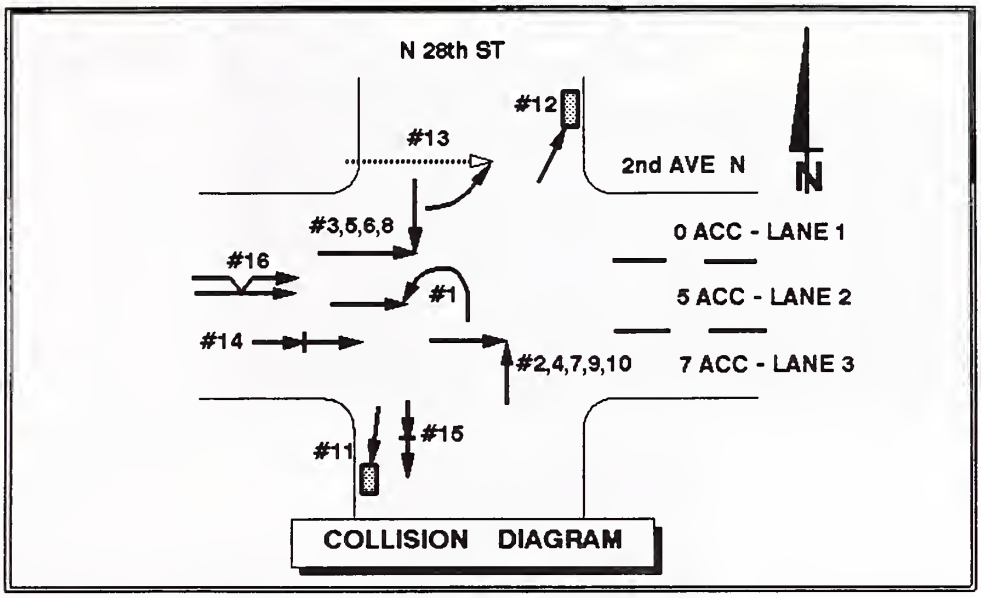
17

SECOND AVENUE N.

and

N. 28TH STREET

ACCIDENT SUMMARY
SECOND AVE N & N 28TH STREET



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	7	29	88	1330	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	9	27	88	1534	INJURY	CLEAR	DRY	DAY
3	ANGLE	5	5	89	1026	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	5	9	89	737	INJURY	CLEAR	DRY	DAY
5	ANGLE	7	6	89	1042	INJURY	CLEAR	DRY	DAY
6	ANGLE	9	23	89	1635	INJURY	CLEAR	DRY	DAY
7	ANGLE	9	24	89	408	PROP DAM	CLEAR	DRY	NITE
8	ANGLE	9	30	89	1225	PROP DAM	CLEAR	DRY	NITE
9	ANGLE	11	28	89	908	PROP DAM	CLEAR	DRY	DAY
10	ANGLE	3	23	90	1635	PROP DAM	SNOW	SNOW	DAY
11	PARKED CAR	1	10	88	954	PROP DAM	CLEAR	DRY	DAY
12	PARKED CAR	5	23	88	1505	INJURY	CLEAR	DRY	DAY
13	PEDESTRIAN	10	2	89	1313	PROP DAM	RAIN	WET	DAY
14	REAREND	1	30	88	1417	PROP DAM	SNOW	SNOW	DAY
15	REAREND	2	22	91	1719	PROP DAM	CLEAR	DRY	DAY
16	SIDESWIPE	6	12	89	932	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
5	1988	NO. INJURY	5
9	1989	NO. FATAL	0
1	1990	NO. PDO	11
1	1991	PER INJ=	9
16	TOTAL	NIGHTIME	13%

TYPES	NUMBER	ROAD	
ANGLE	10	DRY	81%
REAR END	2	WET	6%
SIDESWIPE	1	SNOW	13%
PEDESTRIAN	1	ICE	0%
OTHER	2	OTHER	0%

N. 28TH ST. LOOKING NORTH

SECOND AVE. N. LOOKING EAST

N. 28TH ST. LOOKING SOUTH

TRAFFIC OPERATIONS

The intersection of Second Avenue N. and N. 28th Street is a signalized intersection in the core of the CBD. N. 28th Street is a two-way street with turn and thru lanes signed and marked. Second Avenue is a one-way street with three traffic lanes. There is parking on the both sides of both streets. Vehicular speeds are low and pedestrian traffic is high. There is a significant amount of turning movements at this intersection.

The most obvious condition noticed at this intersection is that the northbound thru lane overlaps into the southbound left turn lane, a situation which could not be eliminated without prohibiting parking for a significant distance and parking spaces are at a premium in this area. The signal is part of a coordinated system in the CBD. The system runs on a 70 second cycle from 7:30 to 5:30 and a 55 second cycle the remainder of the day. Progression is set on Second Avenue North. Because of heavy turning movements and pedestrian traffic, the center lane is usually the only traffic lane that fully enjoys this progression during peak hour periods.

There were ten angle accidents during the reporting period. These accidents were split between northbound and southbound movements. Slick roads were not a factor in these accidents.

IMPROVEMENTS

Two recommendations are made to reduce the potential for angle accidents and potentially, rearend accidents. The all-red interval should be increased to 1.5 seconds. Because of the background cycle and similar accident experience at adjacent intersections it may be desirable to reset all of the signals on 2nd Avenue as well. In addition, existing mast arm signal heads should be replaced with 12"X12"x12" signal heads and in the case of northbound and southbound signals, the existing heads could be reused as a second mast arm indications to increase street approach coverage.

Use of the larger signal heads is recommended within this study for specific reasons. The 12"x8"x8" signal indication has been used widely within the past ten to twenty years and rarely is a 12"x12"x12' indication used. There is

much controversy over the need for a straight 12" signal head and thus far no statistics are available to support claims either way. A logical examination of their use may shed more light on the subject. A 12" red lens only serves those drivers who have already seen the yellow; those who are already stopped; and those who are approaching and are anticipating the change to green. Twelve inch green lenses improve visibility for those who are approaching the signal by alerting them to the presence of a signal; providing information which can be used to calculate desired speed; and alerting them to the potential for change. The twelve inch yellow improves visibility for approaching drivers and serves to alert them that the red stop condition in imminent and allows them to decide the proper course of action. When these facts are considered, use of a 12" red lense for improved visibility is not nearly as important as use of 12" yellow and green lenses. As far as driver perception and reaction is concerned, need for the red lense is nearly always after the fact. In other words, when the red lense is illuminated, it is too late for any safe action other than to remained stopped.

SECOND AVENUE N & N. 28TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	7900
SOUTH APP	8700
EAST APP	8100
WEST APP	9000

EXISTING CONTROL:

NONE	
YIELD	
STOP	
SIGNAL	YES

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	
SIGNAL	YES
MARKING	
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$3,840
MDoT FUND	$400
CITY FUND	$3,440

% ACCIDENT REDUCTION:

INJ/FTL	20%
PDO	15%

BENEFIT/COST RATIO: 9.5

	INDEX VALUE	SITE RANK
# ACCIDENTS	79	8
ACCIDENT RATE	20	24
SEVERITY	58	2
VOL/CAPACITY	69	28
SIGHT DIST.	50	13
DRIVER EXPECT	67	13
INFO DEFICIENT	67	7
HAZARD INDEX	55.4	15
B/C RATIO	49	16

PRIORITY	53.29	17

SITE

NUMBER

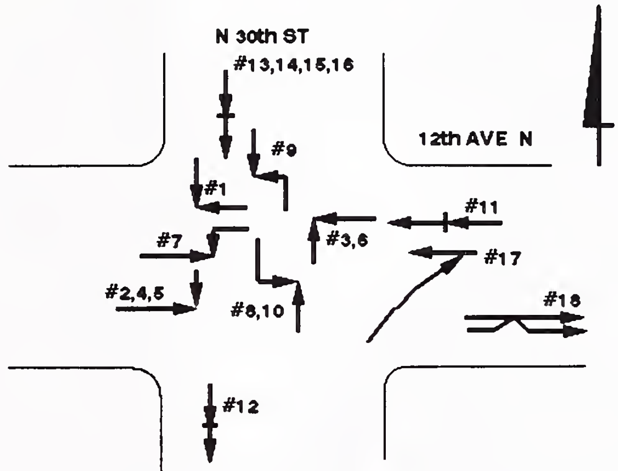
18

TWELFTH AVENUE N.

and

N. 30TH STREET

ACCIDENT SUMMARY
TWELFTH AVE N 7 N 30TH STREET



COLLISION DIAGRAM

ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	4	1	88	1549	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	11	5	88	410	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	3	22	90	1714	INJURY	CLEAR	ICY	DAY
4	ANGLE	6	14	90	1634	INJURY	CLEAR	DRY	DAY
5	ANGLE	3	5	91	1110	PROP DAM	SNOW	ICY	DAY
6	ANGLE	3	26	91	832	PROP DAM	CLEAR	WET	DAY
7	LEFT TURN	1	6	88	900	INJURY	CLEAR	ICY	DAY
8	LEFT TURN	7	30	90	714	INJURY	CLEAR	DRY	DAY
9	LEFT TURN	9	5	90	1404	PROP DAM	CLEAR	DRY	DAY
10	LEFT TURN	9	21	90	1747	PROP DAM	CLEAR	DRY	DAY
11	REAREND	3	31	88	1718	PROP DAM	CLEAR	DRY	DAY
12	REAREND	1	24	89	942	PROP DAM	CLEAR	ICY	DAY
13	REAREND	12	20	89	1450	PROP DAM	SNOW	ICY	DAY
14	REAREND	1	24	91	1236	PROP DAM	SNOW	ICY	DAY
15	REAREND	1	24	91	1517	INJURY	SNOW	ICY	DAY
16	REAREND	2	5	91	1350	PROP DAM	CLEAR	DRY	DAY
17	SIDESWIPE	12	18	90	1818	PROP DAM	CLEAR	ICY	DAY
18	SIDESWIPE	3	21	91	1549	PROP DAM	RAIN	WET	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
4	1988	NO. INJURY	5
2	1989	NO. FATAL	0
6	1990	NO. PDO	13
6	1991	PER INJ=	5
18	TOTAL	NIGHTIME	6%

TYPES	NUMBER	ROAD	
ANGLE	6	DRY	44%
REAREND	6	WET	11%
SIDESWIPE	2	SNOW	0%
LEFT TRN	4	ICE	44%
OTHER	0	OTHER	0%


N. 30TH ST. LOOKING NORTH


N. 30TH ST. LOOKING SOUTH


TWELFTH AVE. N. LOOKING EAST


TWELFTH AVE. N. LOOKING WEST

TRAFFIC OPERATIONS

North 30th Street is a minor arterial north-south street within the original townsite grid orientation. Its intersection with 12th Avenue North is one of two intersections on N.30th Street analyzed within this study. The N. 30th Street corridor is evaluated within the main body of this report. Twelfth Avenue N. is a local east-west street which has heavy use from circulation traffic in the medical corridor area. Saint Vincent's Hospital is in the northeast corner of this intersection.

There are many problems associated with this intersection. The most obvious problem observed was sight distance. The most critical location in this respect is the northwest corner where a 4' retaining wall and a MET bus shelter completely obscures the line of sight for drivers entering the intersection from the west. All other quadrants of the intersection also have sight distance obstructions, the most common of which is parked cars and on-street parking in this area is in heavy demand. At certain times of the day on-street parking fills every available space. The parked vehicles make it very difficult for vehicles on the side street to view traffic on N. 30th Street.

The sight distance obstructions are further complicated by heavy vehicular turning movements and numerous pedestrian crossings. Drivers on the side streets must try to keep track of pedestrians crossing at the intersection while trying to position their vehicle to see oncoming traffic. These activities are compounded by turning vehicles which have to wait for opposing traffic and block the view of thru vehicles which are able to pass on the right because of the wide streets. N. 30th Street is also on a 4% grade which causes problems in inclement weather conditions. Turning vehicles which slow for the maneuver and vehicles who react to side streets vehicles which have pulled into the intersection create high accident potential. There were six angle accidents, four left turn accidents and six rearend accidents at this location during the reporting period. Forty four percent of those accidents were on icy streets. These statistics relate directly to the conditions and operations found at this site.

IMPROVEMENTS

Higher speeds on N. 30th along with parked cars and a wide street combine to increase the required intersection sight distance. A single unit design vehicle acceleration model was developed to determine critical traffic gaps and required sight distances at this intersection. By applying these distances to the intersection layout plan, restricted parking zones were determined. Existing parking restrictions, in some cases, were very close to those calculated. Because of high traffic and pedestrian volumes at this location, a traffic signal warrant analysis was completed. A summary of that analysis can be found at the end of this section. None of the signal warrants were met, but the combination of warrants is within 20% of being met.

Permanent sight obstructions and traffic operations require significant improvements in addition to parking restrictions. Corner island bulbs are necessary to allow side street traffic to enter farther into the intersection without crowding pedestrian cross walks. This will also provide shorter pedestrian crossing distances on N. 30th Street. Extending the corner islands into 12th Avenue would also benefit pedestrian crossings, but it would not considered a critical improvement and should be considered optional.

The bus shelter in the northwest corner may function well for bus patrons, but it is definitely obscures the necessary line of sight. In addition, buses stopping at this corner are the worst possible sight restriction. It is recommended that a modified bus turn-out be constructed within the boulevard area at this location and the bus shelter be moved to the north end of the turn-out.

Within the improved street section, it is recommended that the street be marked to provide left turn bays on N. 30th Street. This will allow storage area for left turning vehicles and side street traffic will have the knowledge that thru vehicles will definitely be passing on the right. The bay transitions will allow a better view of oncoming traffic's location and intent.

Costs to implement these improvements are fairly substantial, considering it is a short term improvement. However, the recommendations correlates well with the N. 30th Street corridor improvements and construction of the physical

improvements will have a longer life span than normal short term improvements. Since Saint Vincents is currently developing a master plan for growth in this area, it might be advisable to coordinate these improvements. Construction of these recommendation also have aesthetic possibilities for landscaping in the wider boulevard and island bulb areas. Whatever long term improvements are considered in this area, it should be remembered that traffic safety should be of paramount importance. From this study and other similar studies in Montana communities, it has been observed that accidents appear to cluster near medical facilities. This fact is believed to be related to the state of mind that a higher percentage of drivers may be in, while they are in the area. Whether area drivers are elderly, receiving treatment or just visiting patients, their conscious thoughts are almost certainly occupied on other matters beside driving. Future improvements at this intersection should recognize this potential problem and all traffic facilities should be designed with a simplicity that allows maximum use of the driver's visual senses.

TWELFTH AVENUE N & N. 30TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	6400
SOUTH APP	5100
EAST APP	3100
WEST APP	1200

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	YES

ESTIMATED COST:

TOTAL	$20,990
MDoT FUND	$350
CITY FUND	$20,640

% ACCIDENT REDUCTION:

INJ/FTL	62%
PDO	53%

BENEFIT/COST RATIO: 5.2

	INDEX VALUE	SITE RANK
# ACCIDENTS	82	6
ACCIDENT RATE	41	12
SEVERITY	47	11
VOL/CAPACITY	57	8
SIGHT DIST.	100	4
DRIVER EXPECT	67	15
INFO DEFICIENT	63	12
HAZARD INDEX	60.7	3
B/C RATIO	36	21

PRIORITY	52.55	18

TRAFFIC SIGNAL WARRANT ANALYSIS
YEAR 1991
TWELFTH AVE. N. & N. 30TH STREET

WARRANT #1 - MINIMUM VEHICULAR VOLUME					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		500	150	385	95
% OF WARRANT MET				77%	63%

WARRANT #2 - INTERRUPTION OF CONTINOUS TRAFFIC					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		750	75	385	95
% OF WARRANT MET				51%	127%

WARRANT #3 - MINIMUM PEDESTRIAN TRAFFIC					
50% WARRANT		REQUIRED		EXISTS	
YES	NO	PEDS	GAPS	PEDS	GAPS
FOUR HOURS		100	60	20	70
PEAK HOUR		190	60	24	58
% OF WARRANT MET				13%	103%

WARRANT #4 - SCHOOL CROSSING [STUD	YES	NO

WARRANT #5 - PROGRESSIVE MOVEMENT	YES	NO

WARRANT #6 - ACCIDENT EXPERIENCE	YES	NO

WARRANT #7 - SYSTEMS WARRANT	YES	NO

WARRANT #8 - COMBINATION OF WARRANTS				
80 % OF	REQUIRED		EXISTS	
WARRANTS #1 & #2	MAJOR	MINOR	MAJOR	MINOR
WARRANT #1	400	120	385	95
WARRANT #2	600	60	385	95
% OF WARRANT MET			80%	119%

WARRANT #9 - FOUR HOUR VOLUMES				
	MAJOR	MINOR	CURVE NO.	WARRAN
4TH HIGHEST HOUR	460	110	FIGURE	YES
NUMBER OF LANES	2	2	4.7	NO

WARRANT #10 - PEAK HOUR DELAY				
PEAK HOUR:	MINOR LEG		TOTAL ENTERING	
	DELAY	VOLUME	4 LEGS	3 LEGS
REQUIRED VALUES	4	100	800	650
EXISTING VALUES	1	155	1400	

WARRANT #11 - PEAK HOUR VOLUME				
	MAJOR	MINOR	CURVE NO.	WARRAN
PEAK HOUR	640	155	FIGURE	YES
NUMBER OF LANES	1	1	4.5	NO

SUMMARY OF WARRANTS SATISFIED					
WARRANT 1		WARRANT 5		WARRANT 9	
WARRANT 2		WARRANT 6		WARRANT 10	
WARRANT 3		WARRANT 7		WARRANT 11	
WARRANT 4		WARRANT 8		TOTAL =	0

SITE

NUMBER

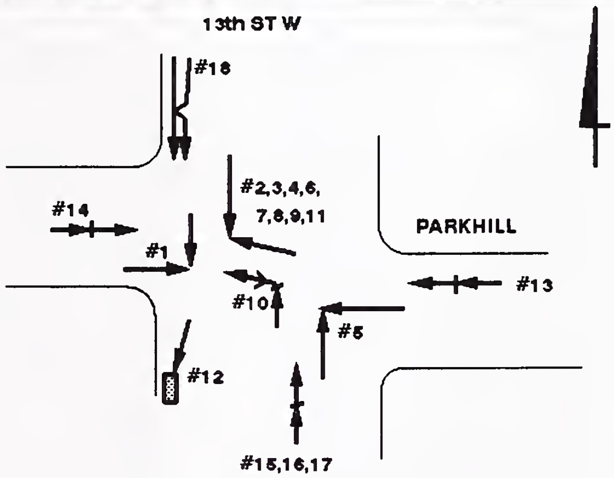
19

PARKHILL DRIVE

and

13TH STREET WEST

ACCIDENT SUMMARY
PARKHILL AVE & 13TH STREET W



COLLISION DIAGRAM

ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	5	11	88	755	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	5	21	88	1211	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	5	11	89	1341	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	5	19	89	1649	INJURY	CLEAR	DRY	DAY
5	ANGLE	1	7	90	1210	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	6	15	90	1433	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	7	7	90	1434	PROP DAM	CLEAR	DRY	DAY
8	ANGLE	7	31	90	20	PROP DAM	CLEAR	DRY	NITE
9	ANGLE	4	14	91	1323	PROP DAM	CLEAR	WET	DAY
10	BACKING	5	11	89	1343	PROP DAM	CLEAR	DRY	DAY
11	LEFT TURN	3	23	90	1537	INJURY	SNOW	ICY	DAY
12	PARKED CAR	6	3	90	1834	PROP DAM	CLEAR	DRY	DAY
13	REAREND	5	7	89	1520	PROP DAM	CLEAR	DRY	DAY
14	REAREND	9	11	89	801	PROP DAM	CLEAR	DRY	DAY
15	REAREND	3	2	90	1506	PROP DAM	CLEAR	DRY	DAY
16	REAREND	5	27	90	1626	PROP DAM	CLEAR	DRY	DAY
17	REAREND	9	19	90	1210	PROP DAM	CLEAR	DRY	DAY
18	SIDESWIPE	6	11	90	1753	INJURY	SNOW	WET	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	3
5	1989	NO. FATAL	0
10	1990	NO. PDO	15
1	1991	PER INJ=	5
18	TOTAL	NIGHTIME	6%

TYPES	NUMBER	ROAD	
ANGLE	9	DRY	78%
REAREND	5	WET	11%
SIDESWIPE	1	SNOW	6%
LEFT TRN	1	ICE	6%
OTHER	2	OTHER	0%

13TH ST. W. LOOKING NORTH

13TH ST. W. LOOKING SOUTH

PARKHIL DR. LOOKING EAST

PARKHILL DR. LOOKING WEST

TRAFFIC OPERATIONS

Parkhill Drive is an east-west collector street and 13th Street West is a north-south minor arterial street. The most distinguishing feature of their intersection is a 40' offset jog in the parkhill alignment. This intersection has been identified as one of the highest accident problem areas in Billings in the Transportation Plan and all subsequent City safety project studies. Within the transportation plan TSM element, improvements call for signalization and realignment of the Parkhill alignment.

Observations within this study indicate that the jogged alignment plays a significant role in accident experience. The geometry of the intersection requires a longer gap time for crossing vehicles; requires significant driver skill to perform direction changes while accelerating; requires drivers to monitor several vehicle turning movements simultaneously while in the intersection; and requires drivers to consciously sort out potential conflicts with other vehicles. All of the activity at this intersection presents drivers with a classic case of information overload. Nine angle accidents and five rearend accidents within the reporting period illustrate the problems drivers encounter at this site.

IMPROVEMENTS

Higher speeds on 13th Street West along with parked cars and a wide street combine to increase the required intersection sight distance. A single unit design vehicle acceleration model was developed to determine critical traffic gaps and required sight distances at this intersection. By applying these distances to the intersection layout plan, restricted parking zones were determined. Existing parking restrictions, in most cases, were very close to those calculated. Because of high traffic and past recommendations at this location, a traffic signal warrant analysis was completed. A summary of that analysis can be found at the end of this section. None of the signal warrants were met, but the combination of warrants is within 12% of being met and peak hour and four hour volume hour volumes are very close to being met. A check into the TSM plan recommendation revealed that traffic volumes,

especially on 13th Street West at this intersection, have fallen. One of the reasons for this reduction, besides a general reduction in traffic citywide, is believed to be improvements on 19th Street West, which have attracted some of the longer trip lengths. Future growth in the Billings area may once again increase traffic volumes at this intersection and a future signal may still be warranted. Since the only signal warrant that may be met in the immediate future would be the accident experience warrant other improvements would have to be implemented first. The most basic improvements at this location would involve realignment of Parkhill through the intersection. The realignment shown on the short term improvements sketch indicate the minimum amount of physical construction necessary. If a longer more land use intensive alignment were used, their would be improved benefits. However, the purpose of this study is short term minimum cost improvements. Along with the realignment, it is considered necessary to mark the street to provide left turn bays. This will help sort out conflicting vehicle movements and provide a storage area which will reduce potential for rearend accidents. It is recommended that design plans and specifications be prepared for these improvements and consideration be given for more extensive construction and future signals.

PARKHILL DRIVE & 13TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	7700
SOUTH APP	8100
EAST APP	3500
WEST APP	3400

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	YES

ESTIMATED COST:

TOTAL	$23,140
MDoT FUND	$1,660
CITY FUND	$21,480

% ACCIDENT REDUCTION:

INJ/FTL	53%
PDO	59%

BENEFIT/COST RATIO: 4.4

	INDEX VALUE	SITE RANK
# ACCIDENTS	82	5
ACCIDENT RATE	31	17
SEVERITY	48	7
VOL/CAPACITY	91	3
SIGHT DIST.	93	10
DRIVER EXPECT	75	4
INFO DEFICIENT	67	6
HAZARD INDEX	62.6	1
B/C RATIO	32	22

PRIORITY	52.50	19

TRAFFIC SIGNAL WARRANT ANALYSIS
YEAR 1991
PARKHILL DRIVE & 13TH STREET W.

WARRANT #1 - MINIMUM VEHICULAR VOLUME					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		500	150	485	105
% OF WARRANT MET				97%	70%

WARRANT #2 - INTERRUPTION OF CONTINOUS TRAFFIC					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		750	75	485	105
% OF WARRANT MET				65%	140%

WARRANT #3 - MINIMUM PEDESTRIAN TRAFFIC					
50% WARRANT		REQUIRED		EXISTS	
YES	NO	PEDS	GAPS	PEDS	GAPS
FOUR HOURS		100	60		
PEAK HOUR		190	60		
% OF WARRANT MET				N/A	

WARRANT #4 - SCHOOL CROSSING [STUD	YES	NO

WARRANT #5 - PROGRESSIVE MOVEMENT	YES	NO

WARRANT #6 - ACCIDENT EXPERIENCE	YES	NO

WARRANT #7 - SYSTEMS WARRANT	YES	NO

WARRANT #8 - COMBINATION OF WARRANTS				
80 % OF	REQUIRED		EXISTS	
WARRANTS #1 & #2	MAJOR	MINOR	MAJOR	MINOR
WARRANT #1	400	120	485	105
WARRANT #2	600	60	485	105
% OF WARRANT MET			101%	88%

WARRANT #9 - FOUR HOUR VOLUMES				
	MAJOR	MINOR	CURVE NO.	WARRAN
4TH HIGHEST HOUR	580	125	FIGURE	YES
NUMBER OF LANES	2	2	4.7	NO

WARRANT #10 - PEAK HOUR DELAY				
PEAK HOUR:	MINOR LEG		TOTAL ENTERING	
	DELAY	VOLUME	4 LEGS	3 LEGS
REQUIRED VALUES	4	100	800	650
EXISTING VALUES	1.5	160	1160	

WARRANT #11 - PEAK HOUR VOLUME				
	MAJOR	MINOR	CURVE NO.	WARRAN
PEAK HOUR	730	160	FIGURE	YES
NUMBER OF LANES	1	1	4.5	NO

SUMMARY OF WARRANTS SATISFIED					
WARRANT 1		WARRANT 5		WARRANT 9	
WARRANT 2		WARRANT 6		WARRANT 10	
WARRANT 3		WARRANT 7		WARRANT 11	
WARRANT 4		WARRANT 8	MARGINAL	TOTAL =	0

SITE

NUMBER

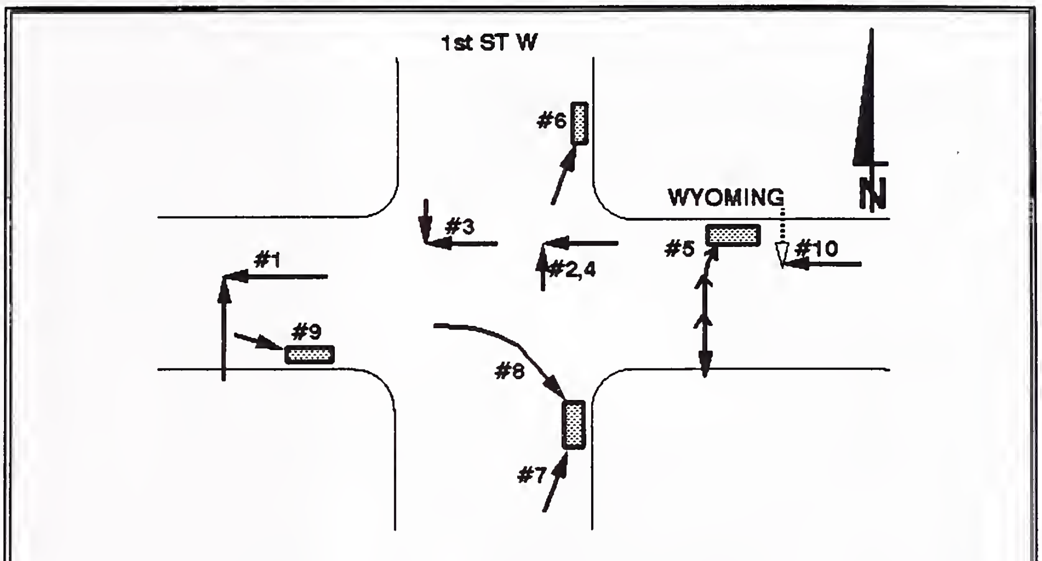
20

WYOMING AVENUE

and

1ST STREET WEST

ACCIDENT SUMMARY
WYOMING AVE & 1ST STREET W



COLLISION DIAGRAM

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
		ACCIDENT KEY							
1	ANGLE	3	4	89	845	PROP DAM	CLEAR	ICY	DAY
2	ANGLE	8	24	89	2200	PROP DAM	SNOW	DRY	NITE
3	ANGLE	1	19	90	1231	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	12	10	90	1105	PROP DAM	CLEAR	DRY	DAY
5	BACKING	11	7	90	1258	PROP DAM	CLEAR	DRY	DAY
6	PARKED CAR	2	1	88	1515	PROP DAM	CLEAR	ICY	NITE
7	PARKED CAR	5	11	88	801	PROP DAM	CLEAR	DRY	DAY
8	PARKED CAR	1	17	90	1358	PROP DAM	SNOW	SNOW	DAY
9	PARKED CAR	4	22	90	217	PROP DAM	CLEAR	DRY	NITE
10	PEDESTRIAN	1	29	91	1530	INJURY	CLEAR	ICY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	1
2	1989	NO. FATAL	0
5	1990	NO. PDO	9
1	1991	PER INJ=	1
10	TOTAL	NIGHTIME	30%

TYPES	NUMBER	ROAD	
ANGLE	4	DRY	60%
REAR END	0	WET	0%
SIDESWIPE	0	SNOW	10%
BIKE/PED	1	ICE	30%
OTHER	5	OTHER	0%

1ST ST. W. LOOKING NORTH

1ST ST. W. LOOKING SOUTH

WYOMING AVE. LOOKING EAST

WYOMING AVE. LOOKING WEST

TRAFFIC OPERATIONS

Wyoming Avenue and 1st Street West are local streets just west of the CBD. First Street West is a north-south street paralleling Division Street which is an arterial on the CBD fringe. First Street West carries more traffic than other local streets in the area because it is the first street west of Division which has continuity between Grand Avenue and Broadwater Avenue, two east-west arterials. It is a wide, smooth street with no traffic controls other than those at Grand, Lewis and Broadwater. Wyoming Avenue is narrower than 1st, but it is also in good condition. A significant amount of westbound traffic on Wyoming Avenue has an origin from Division Street and it is estimated that the majority of traffic is generated by Central High, one block to the east. Observations indicate that drivers on 1st assume that they are on a thru street despite the large amount of traffic on Wyoming. Traffic on Wyoming peaks when school begins, ends and during lunch periods. All on-street parking in the area is 100% occupied during school hours. There is a significant amount of pedestrian traffic during the peak hour periods. Four angle accidents and four parked car accidents characterize the traffic operations found at this intersection.

IMPROVEMENTS

An imbalance in approach traffic volumes at this intersection during most periods of the day and the mix of travel purpose between the two streets indicates that vehicular right-of-way control in the form of stop signs are suited to this intersection. Parking restrictions on 1st Street are also considered necessary to gain necessary sight distance at the intersection. These restrictions will require curb paint and signing because of the heavy parking demand. Stop bars and cross walks will reinforce the stop condition. It is also recommended that the stop signs be placed at a location for maximum visibility and temporary stop ahead signs be used until new driving habits are formed. The City should monitor intersections on 1st, especially Clark Avenue to see if future conditions would warrant designation of 1st as a thru street.

WYOMING AVENUE & 1ST STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1400
SOUTH APP	1400
EAST APP	1500
WEST APP	500

EXISTING CONTROL:

NONE	YES
YIELD	
STOP	
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$1,520
MDoT FUND	$400
CITY FUND	$1,120

% ACCIDENT REDUCTION:

INJ/FTL	5%
PDO	53%

BENEFIT/COST RATIO: 5.8

	INDEX VALUE	SITE RANK
# ACCIDENTS	67	21
ACCIDENT RATE	67	4
SEVERITY	40	22
VOL/CAPACITY	33	12
SIGHT DIST.	46	14
DRIVER EXPECT	71	11
INFO DEFICIENT	67	8
HAZARD INDEX	57.9	11
B/C RATIO	38	19

PRIORITY	51.33	20

SITE

NUMBER

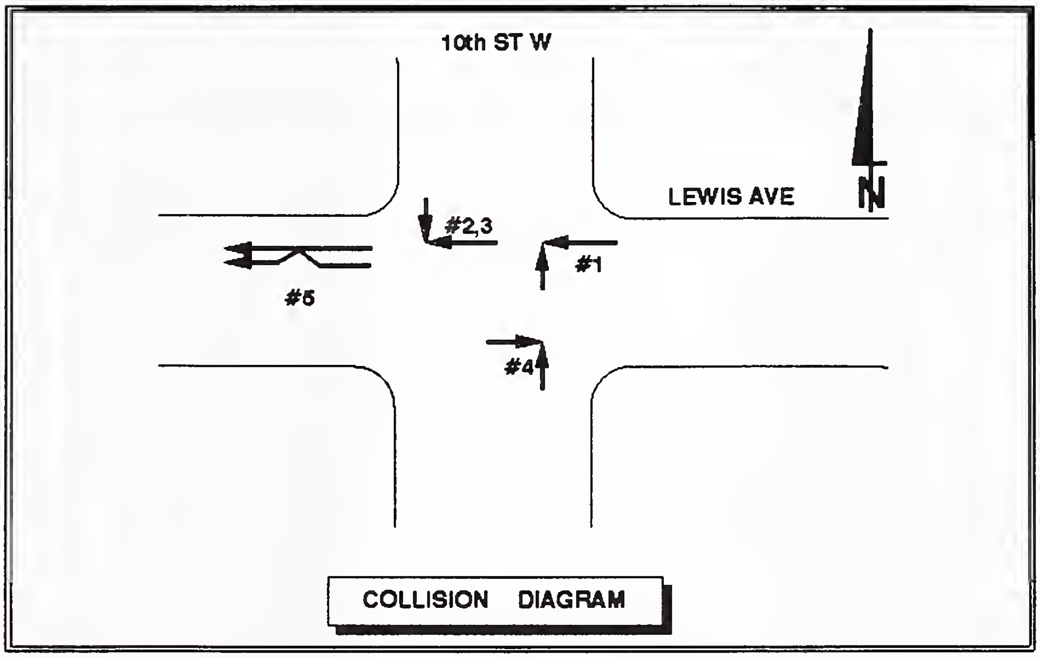
21

LEWIS AVENUE

and

10TH STREET WEST

ACCIDENT SUMMARY
LEWIS AVE & 10TH STREET W



ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
		ACCIDENT KEY							
1	ANGLE	7	26	88	1406	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	3	22	90	819	INJURY	SNOW	ICY	DAY
3	ANGLE	4	24	90	1946	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	1	13	91	1348	PROP DAM	CLEAR	ICY	DAY
5	SIDESWIPE	2	14	89	1515	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
1	1988	NO. INJURY	1
1	1989	NO. FATAL	0
2	1990	NO. PDO	4
1	1991	PER INJ=	1
5	TOTAL	NIGHTIME	0%

TYPES	NUMBER	ROAD	
ANGLE	4	DRY	60%
REAR END	0	WET	0%
SIDESWIPE	1	SNOW	0%
BIKE/PED	0	ICE	40%
OTHER	0	OTHER	0%

10TH ST. W. LOOKING NORTH


10TH ST. W. LOOKING SOUTH


LEWIS AVE. LOOKING EAST


LEWIS AVE. LOOKING WEST

TRAFFIC OPERATIONS

Lewis Avenue is an east-west collector street and 10th Street West is a local north-south street. This section of Lewis Avenue is not within the limits of the Lewis Avenue corridor analysis found within the main body of the report. At this intersection Lewis Avenue is a wide street (51'). Tenth Street is 38' wide and on the south side of the intersection it also serves as a main approach to the Elks Club. Tenth street traffic volumes are relatively low, although slightly higher than the average local street. Traffic on Lewis is relatively high at approximately 10,000 ADT. Parking along both streets is relatively light although the only parked vehicles in the vicinity congregate near the intersection. The stop sign in the northwest corner was partially obscure by a parked pickup truck during field observations. Four angle accidents occurred at this intersection during the reporting period. While the number of accidents and accident rate at this intersection is not very high, the occurrence of accidents is persistent enough to cause concern.

IMPROVEMENTS

Because 40% of the accidents happened on icy streets, there is an indication that sight distance is marginal most of the time and critical when street conditions worsen. In order to improve sight distance for approaching and stopped side street traffic, it is recommended that yellow curb paint and signing be used to restrict parking for 50 feet in advance of the curb radii on Lewis Avenue. A new oversize stop sign should be placed nearer to the curb on a cantilever mount in the northwest corner of the intersection. In addition, stop bars and centerlines should be painted on the approach streets to reinforce the stop condition in the drivers perception of the intersection.

LEWIS AVENUE & 10TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1200
SOUTH APP	1100
EAST APP	9300
WEST APP	10600

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
CONSTRUCT.	

ESTIMATED COST:

TOTAL	$680
MDoT FUND	$340
CITY FUND	$340

% ACCIDENT REDUCTION:

INJ/FTL	30%
PDO	23%

BENEFIT/COST RATIO: 9.0

	INDEX VALUE	SITE RANK
# ACCIDENTS	50	25
ACCIDENT RATE	11	25
SEVERITY	44	15
VOL/CAPACITY	32	14
SIGHT DIST.	100	7
DRIVER EXPECT	75	5
INFO DEFICIENT	71	5
HAZARD INDEX	48.3	24
B/C RATIO	48	18

PRIORITY	48.20	21

SITE

NUMBER

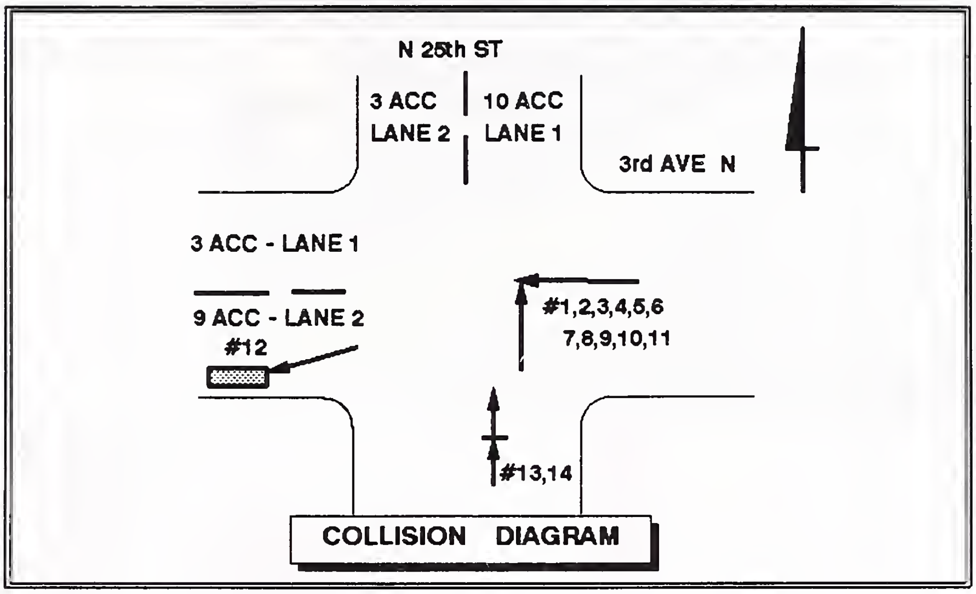
22

THIRD AVENUE N.

and

N. 25TH STREET

ACCIDENT SUMMARY
THIRD AVE N & N 25TH STREET



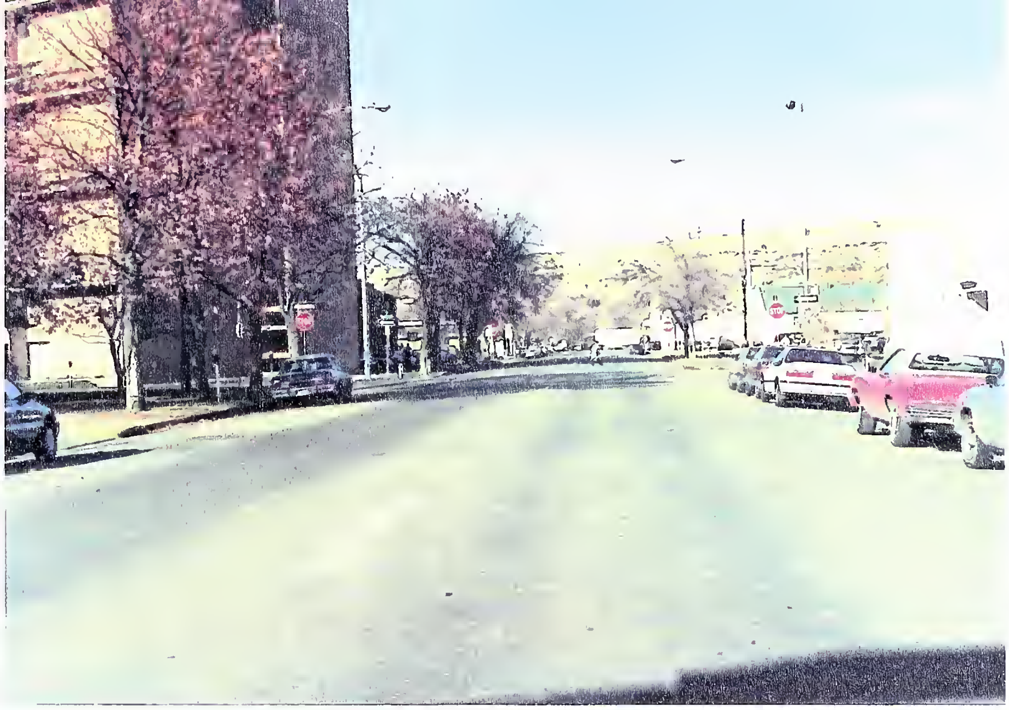
ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	5	2	88	1514	PROP DAM	CLEAR	DRY	DAY
2	ANGLE	5	26	88	1211	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	3	3	89	1500	INJURY	CLEAR	SNOW	DAY
4	ANGLE	4	13	89	907	PROP DAM	CLEAR	DRY	DAY
5	ANGLE	4	13	89	1513	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	8	8	89	1145	PROP DAM	CLEAR	DRY	DAY
7	ANGLE	10	9	89	1422	PROP DAM	CLEAR	DRY	DAY
8	ANGLE	10	23	89	1106	PROP DAM	CLEAR	DRY	DAY
9	ANGLE	12	18	90	1333	PROP DAM	SNOW	ICY	DAY
10	ANGLE	12	21	90	1340	PROP DAM	CLEAR	ICY	DAY
11	ANGLE	4	8	91	1057	PROP DAM	SNOW	WET	DAY
12	PARKED CAR	12	15	90	2215	PROP DAM	CLEAR	ICY	NITE
13	REAREND	2	23	90	1329	PROP DAM	CLEAR	DRY	DAY
14	REAREND	4	10	90	1409	INJURY	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	2
6	1989	NO. FATAL	0
5	1990	NO. PDO	12
1	1991	PER INJ=	2
14	TOTAL	NIGHTIME	7%

TYPES	NUMBER	ROAD	
ANGLE	11	DRY	64%
REAR END	2	WET	7%
SIDESWIPE	0	SNOW	7%
PEDESTRIAN	0	ICE	21%
OTHER	1	OTHER	0%



N. 25TH ST. LOOKING NORTH

THIRD AVE. N. LOOKING EAS

THIRD AVE. N. LOOKING WEST

TRAFFIC OPERATIONS

Third Ave N. and N. 25th Streets are two one-way CBD streets. Third Avenue is one-way westbound and N. 25th is one-way northbound. Both streets are not typical of streets in the CBD since they both have two, instead of three, traffic lanes in a 50' street section with parking on both sides. Pedestrian activity at this location is fairly heavy and requires vehicles to stop well behind the curb radii which limits sight distance along the intersecting street. Since a significant number of intersections in the CBD are signalized, this is not usually a major problem. In this case, northbound traffic is controlled by stop signs. The existence of wide streets, multi-lanes and curb side parking combine to present high probability conditions for angle accidents.

There were 11 angle accidents during the reporting period, two rearend accidents, and one parked car accident at this intersection. Three of the angle accidents were confirmed to be vehicles which had stopped before entering the intersection. The remainder either didn't stop completely or blew right through.

IMPROVEMENTS

Because of lower traffic volumes at this intersection a signal warrant analysis was not completed. The only viable improvements that would prove to have measurable effectiveness would be one which increases the intersection sight distance for the stop street. A dynamic vehicle model using average acceleration rate for a single unit design vehicle was used to calculate critical gaps and required sight distance. Based on this analysis, parking would have to be removed for a half block to attain required sight distance and this intersection is located in an area where parking is at a premium. As an alternative, bulb island curbs on the south side of the street was evaluated. Because this alternative would only remove one parking space; reduce the critical vehicular crossing gap; reduce the width of crossing for pedestrians;

and provide an improved location to mount stop signs, it is the recommended improvement. New stop signs should be oversized to catch drivers attention which is important at this location where drivers are required to monitor a number of different activities beyond navigation.

These improvements are more costly than other short term improvements, but the expected benefits are high. Reconstruction of the curb line may also provide opportunities for street scape improvements if the City would so desire.

THIRD AVENUE N & N. 25TH STREET

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	1450
SOUTH APP	2900
EAST APP	5300
WEST APP	6800

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	YES
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	
CONSTRUCT.	YES

ESTIMATED COST:

TOTAL	$7,706
MDoT FUND	$420
CITY FUND	$7,286

% ACCIDENT REDUCTION:

INJ/FTL	40%
PDO	52%

BENEFIT/COST RATIO: 5.6

	INDEX VALUE	SITE RANK
# ACCIDENTS	76	13
ACCIDENT RATE	38	13
SEVERITY	42	20
VOL/CAPACITY	47	10
SIGHT DIST.	58	11
DRIVER EXPECT	67	12
INFO DEFICIENT	58	15
HAZARD INDEX	53.6	16
B/C RATIO	37	21

PRIORITY	48.12	22

SITE

NUMBER

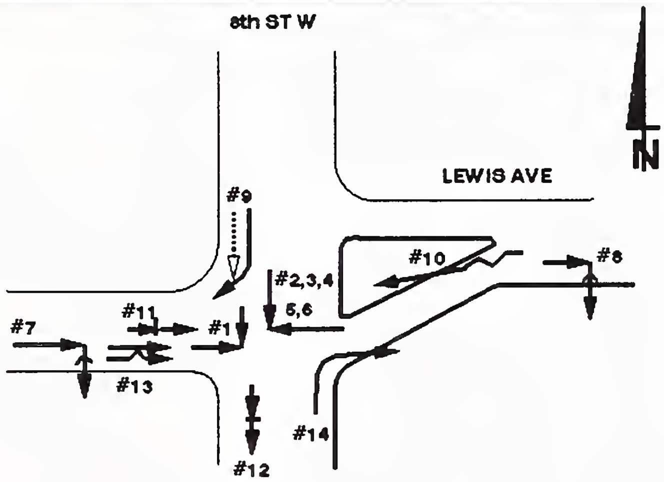
23

LEWIS AVENUE

and

8TH STREET WEST

ACCIDENT SUMMARY
LEWIS AVE & 8TH STREET W



COLLISION DIAGRAM

ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	2	2	88	1823	PROP DAM	SNOW	ICY	NITE
2	ANGLE	5	31	88	1300	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	2	2	90	1432	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	3	21	90	1318	PROP DAM	CLEAR	WET	DAY
5	ANGLE	5	11	90	1759	PROP DAM	CLEAR	DRY	DAY
6	ANGLE	8	22	90	1148	INJURY	CLEAR	DRY	DAY
7	BACKING	3	7	89	740	PROP DAM	CLEAR	ICY	DAY
8	BACKING	10	3	89	1410	PROP DAM	CLEAR	DRY	DAY
9	BIKE	6	22	90	1850	INJURY	CLEAR	DRY	DAY
10	FIXED OBJ	10	17	89	2335	INJURY	CLEAR	DRY	NITE
11	REAREND	2	1	89	1624	PROP DAM	SNOW	ICY	DAY
12	REAREND	1	24	91	1730	PROP DAM	SNOW	ICY	DAY
13	SIDESWIPE	5	34	90	821	PROP DAM	CLEAR	DRY	DAY
14	SINGLE VEH	12	2	88	1741	PROP DAM	CLEAR	DRY	NITE

ACCIDENT STATISTICS

NO. ACC.	YEAR		
3	1988	NO. INJURY	3
4	1989	NO. FATAL	0
6	1990	NO. PDO	11
1	1991	PER INJ=	4
14	TOTAL	NIGHTIME	21%

TYPES	NUMBER	ROAD	
ANGLE	6	DRY	64%
REAR END	2	WET	7%
SIDESWIPE	1	SNOW	0%
BIKE/PED	1	ICE	29%
OTHER	4	OTHER	0%

8TH ST. W. LOOKING NORTH

8TH ST. W. LOOKING SOUTH

LEWIS AVE. LOOKING EAST

LEWIS AVE. LOOKING WEST

TRAFFIC OPERATIONS

Lewis Avenue is an east-west collector street and 8th Street West is a north-south collector. Because of an offset jog in the Lewis Avenue alignment this intersection was reconstructed approximately 18 years ago. A S.I.D. utility project reconstructed the western approach to this intersection in 1990. A portion of the accident experience occurred prior to the 1990 project and some accident exposure was missing during the period when the intersection was closed. The most predominant accident at this intersection was the angle accident, with 6 occurring during the reporting period. Various other types of accidents occurred which reflects the complex nature of this intersection.

IMPROVEMENTS

Because of the high traffic volumes at this intersection, a signal warrant analysis was completed. A summary of that analysis can be found in the back of this section. It was determined that warrant #8, Combination of Warrants and warrant # 10, Peak Hour Delay warrants are met and warrants # 1,9 and 11 are so close as to be marginal. Because of these warrants, a signal could be justified for this intersection. However, the intersection is located on the down side of an inadequate vertical curve (to the north) on 8th and is on a 6% grade. It may be that a signal installation would create more safety problems than it would solve.

Various methods of reducing the Lewis Avenue crossing distance and reconfiguring the intersection were made in attempt to reduce accident potential at this intersection. No alternative was found which would accomplish this task. The only short term improvements that can be recommended at this location deal with upgrading signing and striping to current recommended standards. Plastic marks should replace paint wherever possible since traffic volumes are high and the existing painted marks wear very quickly. Since a significant percentage of accidents occurred at night, it is recommended that improved lighting be installed in the intersection area. The intersection crossing gaps are critical and lighting will aid in driver's perception of approaching vehicle speeds. Future improvements will most likely require extensive reconstruction and right-of-way acquisition in this area if traffic volumes continue to increase.

LEWIS AVENUE & 8TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	7800
SOUTH APP	8700
EAST APP	5500
WEST APP	6200

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
REGULATORY	YES
LIGHTING	YES

ESTIMATED COST:

TOTAL	$8,040
MDoT FUND	$500
CITY FUND	$7,540

% ACCIDENT REDUCTION:

INJ/FTL	17%
PDO	12%

BENEFIT/COST RATIO: 2.3

	INDEX VALUE	SITE RANK
# ACCIDENTS	76	12
ACCIDENT RATE	21	22
SEVERITY	48	8
VOL/CAPACITY	100	1
SIGHT DIST.	51	12
DRIVER EXPECT	83	1
INFO DEFICIENT	67	10
HAZARD INDEX	58.2	8
B/C RATIO	18	23

PRIORITY	44.93	23

TRAFFIC SIGNAL WARRANT ANALYSIS
YEAR 1991
LEWIS AVENUE & 8TH STREET WEST

WARRANT #1 - MINIMUM VEHICULAR VOLUME					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		500	200	540	195
% OF WARRANT MET				108%	98%

WARRANT #2 - INTERRUPTION OF CONTINOUS TRAFFIC					
70% WARRANT		REQUIRED		EXISTS	
YES	NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR		750	100	540	195
% OF WARRANT MET				72%	195%

WARRANT #3 - MINIMUM PEDESTRIAN TRAFFIC					
50% WARRANT		REQUIRED		EXISTS	
YES	NO	PEDS	GAPS	PEDS	GAPS
FOUR HOURS		100	60		
PEAK HOUR		190	60		
% OF WARRANT MET				N/A	

WARRANT #4 - SCHOOL CROSSING [STUD	YES	NO
WARRANT #5 - PROGRESSIVE MOVEMENT	YES	NO
WARRANT #6 - ACCIDENT EXPERIENCE	YES	NO
WARRANT #7 - SYSTEMS WARRANT	YES	NO

WARRANT #8 - COMBINATION OF WARRANTS				
80 % OF	REQUIRED		EXISTS	
WARRANTS #1 & #2	MAJOR	MINOR	MAJOR	MINOR
WARRANT #1	400	160	540	195
WARRANT #2	600	80	540	195
% OF WARRANT MET			113%	122%

WARRANT #9 - FOUR HOUR VOLUMES				
	MAJOR	MINOR	CURVE NO.	WARRAN
4TH HIGHEST HOUR	650	230	FIGURE	YES
NUMBER OF LANES	1	2	4.7	NO

WARRANT #10 - PEAK HOUR DELAY				
PEAK HOUR:	MINOR LEG		TOTAL ENTERING	
	DELAY	VOLUME	4 LEGS	3 LEGS
REQUIRED VALUES	4	100	800	650
EXISTING VALUES	5.2	300	1150	

WARRANT #11 - PEAK HOUR VOLUME				
	MAJOR	MINOR	CURVE NO.	WARRAN
PEAK HOUR	850	300	FIGURE	YES
NUMBER OF LANES	1	2	4.5	NO

SUMMARY OF WARRANTS SATISFIED					
WARRANT 1	MARGINAL	WARRANT 5		WARRANT 9	MARGINAL
WARRANT 2		WARRANT 6		WARRANT 10	YES
WARRANT 3		WARRANT 7		WARRANT 11	MARGINAL
WARRANT 4		WARRANT 8	YES	TOTAL =	2

SITE

NUMBER

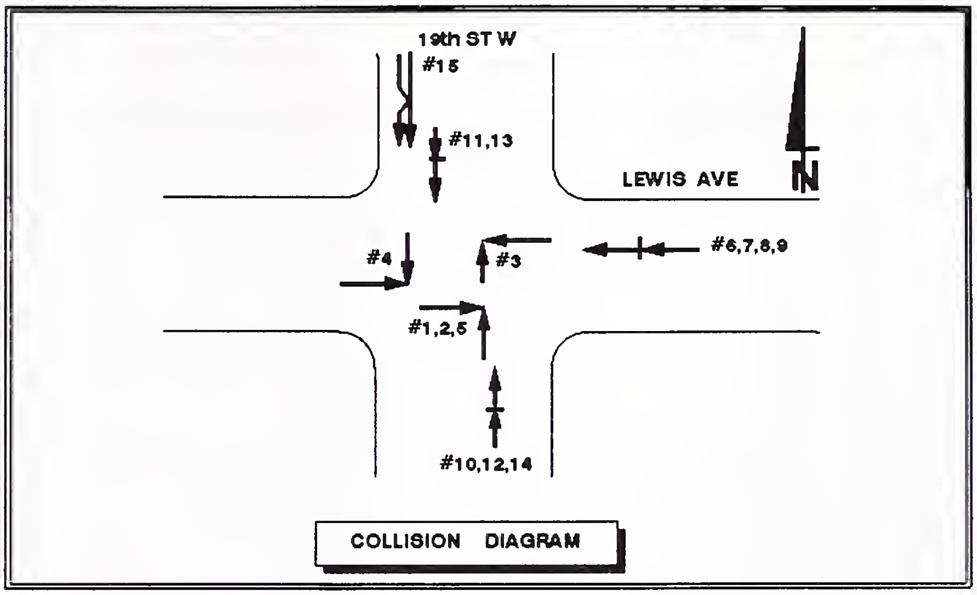
24

LEWIS AVENUE

and

19TH STREET WEST

ACCIDENT SUMMARY
LEWIS AVE & 19TH STREET W



ACCIDENT KEY

ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	1	6	89	1143	PROP DAM	SNOW	SNOW	DAY
2	ANGLE	2	5	90	825	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	11	15	90	1306	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	12	21	90	2026	PROP DAM	CLEAR	ICY	NITE
5	ANGLE	1	24	91	952	PROP DAM	SNOW	ICY	DAY
6	REAREND	8	1	88	1712	PROP DAM	CLEAR	DRY	DAY
7	REAREND	9	7	88	1600	PROP DAM	CLEAR	DRY	DAY
8	REAREND	12	20	89	1536	PROP DAM	SNOW	ICY	DAY
9	REAREND	12	21	89	1400	PROP DAM	CLEAR	DRY	DAY
10	REAREND	2	9	90	1253	PROP DAM	CLEAR	WET	DAY
11	REAREND	3	22	90	815	PROP DAM	SNOW	ICY	DAY
12	REAREND	8	1	90	1445	PROP DAM	CLEAR	DRY	DAY
13	REAREND	11	26	90	955	INJURY	SNOW	SNOW	DAY
14	REAREND	1	24	91	1100	PROP DAM	SNOW	ICY	DAY
15	SIDESWIPE	3	22	90	815	PROP DAM	SNOW	ICY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
2	1988	NO. INJURY	1
3	1989	NO. FATAL	0
8	1990	NO. PDO	14
2	1991	PER INJ=	1
15	TOTAL	NIGHTIME	7%

TYPES	NUMBER	ROAD	
ANGLE	5	DRY	40%
REAR END	9	WET	7%
SIDESWIPE	1	SNOW	13%
BIKE/PED	0	ICE	40%
OTHER	0	OTHER	0%


19TH ST. W. LOOKING NORTH


19TH ST. W. LOOKING SOUTH


LEWIS AVE. LOOKING EAST


LEWIS AVE. LOOKING WEST

TRAFFIC OPERATIONS

Lewis Avenue is an east-west collector street and 19th Street West is a north-south collector. Existing control at this intersection is a four-way stop. This intersection was included as part of a school crossing study in Billings approximately 6 years ago. That study indicated that a signal was not warranted but sufficient school children crossed at this location that cross walks should be marked. Those improvements have never been installed.

Both streets are two lane streets with parking both sides, however there is no significant parking demand in this area. Sight distance for the type of operations involved at this location is good. There are stop ahead signs posted on Lewis in both directions. The need for them is clear, since this intersection is the only stop between 16th Street W. and 24th Street West. Lewis is 51' wide, flat and straight and drivers can easily miss the 30" stop signs. This situation is not as critical on 19th Street West, since it is a narrower street with other stop conditions in closer proximity.

There were 5 angle accidents and nine rearend accidents during the reporting period. It is believed that a portion of the rearend accidents can be attributed to following drivers who were not cognizant of the stop condition. It should also be noted that accidents are increasing progressively with traffic volume increases.

IMPROVEMENTS

Improvements recommended at this intersection focus on improving the chance of Lewis Avenue drivers noticing the stop condition. This can be accomplished by replacing the small faded 30" stop ahead signs with the new standard 36" symbol sign and replacing the existing stop signs with 36" signs. In addition, plastic stop bars and 12" wide crosswalk marking should be installed at this intersection to reinforce the stop condition and to alert drivers that pedestrian crossings are common at this intersection.

Because of the high traffic volumes at this intersection a traffic signal warrant analysis was completed, a summary of which can be found at the end of this section. None of the warrants were met, but it is within 14% of meeting minimum volume warrants and 10% of meeting combination of warrants. Also, peak hour and four hour volumes are close enough to be marginal. Considering recent traffic increases in 19th Street West traffic volumes, it is estimated that minimum signals will be met within the next two years. This projection should not have a bearing on implementation of the short term improvements. Most of these improvements could be used with a new signal installation.

LEWIS AVENUE & 19TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	5200
SOUTH APP	7100
EAST APP	5900
WEST APP	3700

EXISTING CONTROL:

NONE	
YIELD	
STOP	YES
SIGNAL	

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	YES
SIGNAL	
MARKING	YES
WARNING	YES
LIGHTING	

ESTIMATED COST:

TOTAL	$3,760
MDoT FUND	$560
CITY FUND	$3,200

% ACCIDENT REDUCTION:

INJ/FTL	20%
PDO	20%

BENEFIT/COST RATIO: 2.1

	INDEX VALUE	SITE RANK
# ACCIDENTS	78	9
ACCIDENT RATE	27	19
SEVERITY	38	24
VOL/CAPACITY	87	4
SIGHT DIST.	9	25
DRIVER EXPECT	58	20
INFO DEFICIENT	67	9
HAZARD INDEX	50.1	23
B/C RATIO	16	24

PRIORITY	38.85	24

TRAFFIC SIGNAL WARRANT ANALYSIS
YEAR 1991
LEWIS AVENUE & 19TH STREET WEST

WARRANT #1 - MINIMUM VEHICULAR VOLUME				
70% WARRANT	REQUIRED		EXISTS	
YES / NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR	500	150	430	180
% OF WARRANT MET			86%	120%

WARRANT #2 - INTERRUPTION OF CONTINOUS TRAFFIC				
70% WARRANT	REQUIRED		EXISTS	
YES / NO	MAJOR	MINOR	MAJOR	MINOR
8TH HIGHEST HOUR	750	75	430	180
% OF WARRANT MET			57%	240%

WARRANT #3 - MINIMUM PEDESTRIAN TRAFFIC				
50% WARRANT	REQUIRED		EXISTS	
YES / NO	PEDS	GAPS	PEDS	GAPS
FOUR HOURS	100	60	13	
PEAK HOUR	190	60	15	
% OF WARRANT MET			8%	

WARRANT #4 - SCHOOL CROSSING [STUD	YES	NO
WARRANT #5 - PROGRESSIVE MOVEMENT	YES	NO
WARRANT #6 - ACCIDENT EXPERIENCE	YES	NO
WARRANT #7 - SYSTEMS WARRANT	YES	NO

PAGE 1 of 2

WARRANT #8 - COMBINATION OF WARRANTS				
80 % OF	REQUIRED		EXISTS	
WARRANTS #1 & #2	MAJOR	MINOR	MAJOR	MINOR
WARRANT #1	400	120	430	180
WARRANT #2	600	60	430	180
% OF WARRANT MET			90%	150%

WARRANT #9 - FOUR HOUR VOLUMES				
	MAJOR	MINOR	CURVE NO.	WARRAN
4TH HIGHEST HOUR	525	220	FIGURE	YES
NUMBER OF LANES	1	1	4.7	NO

WARRANT #10 - PEAK HOUR DELAY				
PEAK HOUR:	MINOR LEG		TOTAL ENTERING	
	DELAY	VOLUME	4 LEGS	3 LEGS
REQUIRED VALUES	4	100	800	650
EXISTING VALUES	1.8	280	970	

WARRANT #11 - PEAK HOUR VOLUME				
	MAJOR	MINOR	CURVE NO.	WARRAN
PEAK HOUR	670	300	FIGURE	YES
NUMBER OF LANES	1	1	4.5	NO

SUMMARY OF WARRANTS SATISFIED					
WARRANT 1		WARRANT 5		WARRANT 9	MARGINAL
WARRANT 2		WARRANT 6		WARRANT 10	NO
WARRANT 3		WARRANT 7		WARRANT 11	MARGINAL
WARRANT 4		WARRANT 8	MARGINAL	TOTAL =	0

PAGE 2 of 2

SITE

NUMBER

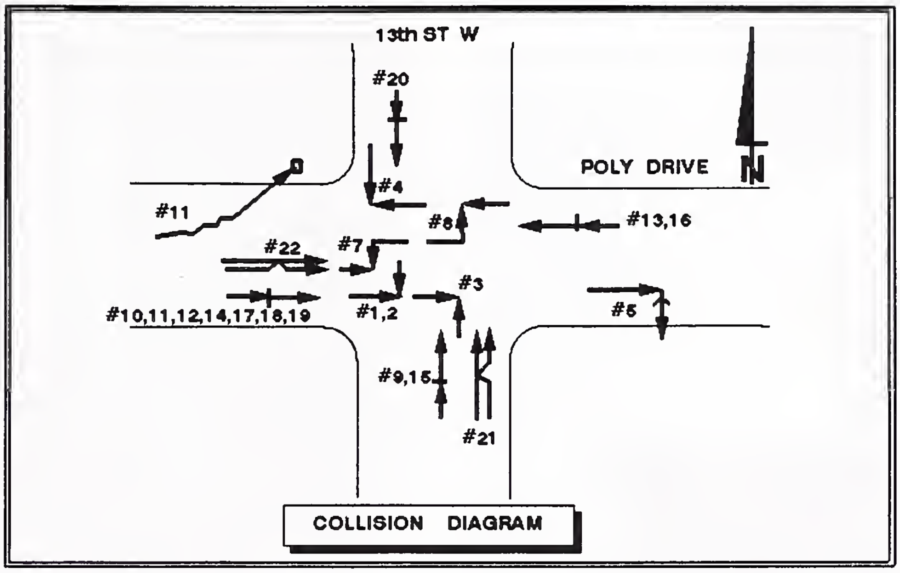
25

POLY DRIVE

and

13TH STREET WEST

ACCIDENT SUMMARY
POLY DRIVE & 13TH STREET W



ACC NO.	ACCIDENT TYPE	MO.	DAY	YEAR	TIME	SEVERITY	WEATHER	ROAD	LIGHT
1	ANGLE	4	25	88	936	PROP DAM	SNOW	WET	DAY
2	ANGLE	6	9	89	1916	PROP DAM	CLEAR	DRY	DAY
3	ANGLE	9	29	90	1000	PROP DAM	CLEAR	DRY	DAY
4	ANGLE	1	9	91	935	PROP DAM	CLEAR	ICY	DAY
5	BACKING	6	14	88	1335	INJURY	CLEAR	DRY	DAY
6	FIXED OBJ	2	13	90	915	PROP DAM	CLEAR	ICY	DAY
7	LEFT TURN	6	26	88	35	INJURY	CLEAR	DRY	NITE
8	LEFT TURN	1	9	89	930	PROP DAM	CLEAR	ICY	DAY
9	REAREND	1	30	88	1330	PROP DAM	SNOW	ICY	DAY
10	REAREND	2	2	88	840	PROP DAM	CLEAR	ICY	DAY
11	REAREND	5	9	88	756	INJURY	CLEAR	DRY	DAY
12	REAREND	7	31	88	1	PROP DAM	CLEAR	DRY	NITE
13	REAREND	9	27	88	1407	PROP DAM	CLEAR	DRY	DAY
14	REAREND	10	21	88	850	PROP DAM	CLEAR	DRY	DAY
15	REAREND	3	17	89	2210	PROP DAM	CLEAR	SNOW	NITE
16	REAREND	4	29	90	1226	PROP DAM	CLEAR	DRY	DAY
17	REAREND	1	24	91	1103	PROP DAM	SNOW	SNOW	DAY
18	REAREND	1	24	91	1104	PROP DAM	SNOW	SNOW	DAY
19	REAREND	1	24	91	1105	PROP DAM	SNOW	SNOW	DAY
20	REAREND	1	24	91	1149	PROP DAM	SNOW	SNOW	DAY
21	SIDESWIPE	9	2	88	1128	PROP DAM	CLEAR	DRY	DAY
22	SIDESWIPE	11	2	89	1425	PROP DAM	CLEAR	DRY	DAY

ACCIDENT STATISTICS

NO. ACC.	YEAR		
10	1988	NO. INJURY	3
4	1989	NO. FATAL	0
3	1990	NO. PDO	19
5	1991	PER INJ=	3
22	TOTAL	NIGHTIME	14%

TYPES	NUMBER	ROAD	
ANGLE	4	DRY	55%
REAR END	12	WET	5%
SIDESWIPE	2	SNOW	18%
LEFT TRN	2	ICE	23%
OTHER	2	OTHER	0%

13TH ST. W. LOOKING NORTH

13TH ST. W. LOOKING SOUTH

POLY DRIVE LOOKING EAST

POLY DRIVE LOOKING WEST

TRAFFIC OPERATIONS

The intersection of Poly Drive and 13th Street West is a signalized intersection. Poly Drive is a minor arterial and 13th Street is a collector street. The area east of the intersection is a residential area to the west is a park and church with open land. Rimrock Elementary School is located on 13th Street approximately 3 blocks north of the intersection and a significant number of school aged pedestrian use the signal crossing. Turning movements at the intersection are heavy.

The most noticeable feature of this intersection is the pavement surface especially on the west side of the intersection. The street cross section was built with a quarter crown in the north portion of the street. Since the south curb line is quite a bit lower than the north curb, the street has a extreme cross slope near the intersection. The combination of cross slope and vehicle deceleration and acceleration has created pavement ridges near the edge of the left turn lane. The ridges are 4 to 6" high in spots. The ridges tend to deflect vehicles even when the road is dry. It was noted that some eastbound thru traffic uses a portion of the left turn lane to avoid those ridges. During periods of snow or ice, thru vehicles use most of the left turn lane because the extreme cross slope can direct the vehicle into the curb. One of two sideswipe accidents and the majority of 12 rearend accidents were attributed to this condition.

With respect to traffic control, there appears to be some signs which do not relate directly to conditions at the intersection and only add to clutter and could distract drivers from critical operations. The signal heads are visible during most approach conditions, but there is only one mast mounted head per pole. Pavement markings are in poor condition. Stop bars, cross walks and words and symbols were completely worn off.

IMPROVEMENTS

The most critical improvement necessary at this intersection appears to be reconstruction of the street section on the west approach. The extreme cross slope and ridges create errant vehicle movements and adds to driver

work load at a juncture which requires drivers to focus on conditions other than vehicle path alignment. Reconstruction of the street section should be extended through the intersection which may aid in eliminating a ramp or dip on the north approach to the intersection. Although no accidents were attributed to this dip, the dip can be severe at approach speeds exceeding 25 mph. Plastic markings should replace all existing painted markings which tend to wear away. The park signs in advance of the intersections should be removed because they only tend to distract drivers from important intersection control.

Signal heads on the mast arms should be replaced with 12"x12"x12" heads. Use of the larger signal heads is recommended within this study for specific reasons. The 12"x8"x8" signal indication has been used widely within the past ten to twenty years and rarely is a 12"x12"x12' indication used. There is much controversy over the need for a straight 12" signal head and thus far no statistics are available to support claims either way. A logical examination of their use may shed more light on the subject. A 12" red lens only serves those drivers who have already seen the yellow; those who are already stopped; and those who are approaching and are anticipating the change to green. Twelve inch green lenses improve visibility for those who are approaching the signal by alerting them to the presence of a signal; providing information which can be used to calculate desired speed; and alerting them to the potential for change. The twelve inch yellow improves visibility for approaching drivers and serves to alert them that the red stop condition in imminent and allows them to decide the proper course of action. When these facts are considered, use of a 12" red lense for improved visibility is not nearly as important as use of 12" yellow and green lenses. As far as driver perception and reaction is concerned, need for the red lense is nearly always after the fact. In other words, when the red lense is illuminated, it is too late for any safe action other than to remained stopped.

POLY DRIVE & 13TH STREET WEST

SITE DATA SUMMARY

TRAFFIC VOLUMES:

	ADT
NORTH APP	4400
SOUTH APP	7800
EAST APP	10500
WEST APP	10500

EXISTING CONTROL:

NONE	
YIELD	
STOP	
SIGNAL	YES

RECOMMENDED CONTROL:

PARKING	
YEILD	
STOP	
SIGNAL	YES
MARKING	YES
REGULATORY	YES
CONSTRUCT.	YES

ESTIMATED COST:

TOTAL	$33,280
MDoT FUND	$280
CITY FUND	$33,000

% ACCIDENT REDUCTION:

INJ/FTL	30%
PDO	37%

BENEFIT/COST RATIO: 1.7

	INDEX VALUE	SITE RANK
# ACCIDENTS	87	2
ACCIDENT RATE	27	20
SEVERITY	41	21
VOL/CAPACITY	63	6
SIGHT DIST.	35	17
DRIVER EXPECT	54	21
INFO DEFICIENT	58	18
HAZARD INDEX	50.4	22
B/C RATIO	12	25

PRIORITY	37.73	25